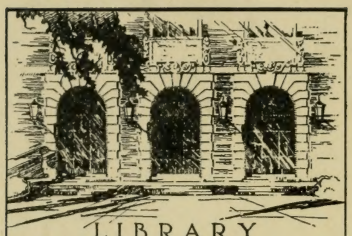

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LOCOMOTIVE APPLIANCES

THIS VOLUME DESCRIBES IMPORTANT ATTACHMENTS USED ON LOCOMOTIVES AND THE RULES AND REGULATIONS FOR THEIR CARE AND OPERATION

FORMING ONE OF THE SERIES OF VOLUMES COMPRISED IN THE REVISED AND ENLARGED EDITION OF

"Kirkman's Science of Railways"

NOTE: The author of "The Science of Railways" served for fifty years as a railway officer and employe; the last twenty years as vice-president of the company. However, in writing "The Science of Railways," and in its many subsequent editions and revisions (to meet the ever changing conditions of the service), he and those interested in the publication of the work have had throughout the active advice and aid of practical experts from every branch of railway operation—men who know, who have themselves solved the problems incident to their particular line of work. The books are, therefore, authoritative, and as valuable to railway men as standard text-books are to lawyers, doctors, civil engineers and other representative men.

REVISED AND ENLARGED EDITION 1916

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INTRODUCTION.

In the case of many mechanical inventions, it has often happened that the machine left the hands of its inventor in its most complicated and cumbrous form, and it remained for the practical man and operator afterward to simplify it, without reducing the advantages of the mechanism as a whole, but rather increasing its efficiency. Thus, in the process of time, the machine, once complex and confusing in its many parts, became shorn of its excrescences, and simplicity rather than complexity characterized its construction. Such, however, has not been the case with the locomotive; early types were entirely lacking in the many appliances that now play so important a part in its operation, and which form the subject of this volume.

Time was, within the memory of many engineers, shopmen and others connected with the mechanical department of railways, when the contents of this volume could have been included in a brief pamphlet. In the early days there was nothing in the cab but the gauge cocks, throttle and reverse lever; upon the outside the attractive features were mainly rings, bands, and casings of polished brass, upon which the fireman lavished much time and labor in burnishing. To-day the locomotive engineer finds in his cab close at hand a multitude of appliances with which he must be familiar in order to be the master of his machine

and compel its prompt and unfailing response to his behests. Within the radius of his arm are a multitude of levers and cocks, the touching of which sets in motion complicated mechanisms that perform some necessary function in the movement of his train. Originally, the engineer's control was limited to his machine; now he is master of the whole train from the headlight to the last truck on the rear of his train. With his injector he controls his water supply; the automatic lubricator has supplanted the hand oiler; the air pump controls the brakes; his steam, air and steam heating gauges keep him advised of the needs of his train in these directions; his speed recorder tells him what work his engine is accomplishing; and so on. Each of these appliances, and many others treated of in this volume, has come into being to meet some apparent need or answer some well defined purpose, and the sum of them all has transformed the locomotive from the rampant, noisy, spasmodic pigmy of its inventor to the graceful, unfailing and swift giant of to-day. When it is remembered that it is but a part of the locomotive engineer's or fireman's business to be informed as to the construction, operation and care of these and many other appliances, it is not surprising that he should be classed among the most skilled artisans of the age.

It is essential that the engineer, fireman, shopman and mechanical student of railways should be familiar with the construction and operation of each of the subsidiary machines and devices, that, taken together, form the perfect modern locomotive, if he hopes to attain success in his profession, and the

aim of this work will be achieved if it makes the purpose, construction, operation and maintenance of locomotive appliances now in general use more clear to those interested.

Any treatise on designs, special attachments or inventions such as the locomotive appliances described herein, must necessarily be largely technical, else it would be untrue to its purpose, but I have not deemed it necessary to burden this book with mathematical formulas understandable only by those who have been initiated into the higher branches of mathematics. Indeed, my object has been to make this treatise so clear and simple that the youngest fireman may comprehend its statements.

In the compilation of this work I have had the benefit of the active advice and invaluable assistance of Mr. Edward Williams Pratt, Mechanical Engineer, a man of talent, and recognized authority on locomotive appliances, and who, in that connection, has been for many years a trusted and highly honored official of one of the largest and best managed railways of the world.

HEADLIGHT.

THE PYLE-NATIONAL ELECTRIC HEADLIGHT.

Rules governing the operation of trains at night require all locomotives to be equipped with efficient headlights; consequently the electric headlight is meeting with universal favor. The headlight is not only expected to indicate a train signal, but furnish sufficient illumination to clearly disclose to the engineer the condition of the track, therefore, the light must be characterized by brilliancy and penetration. The use of the electric headlight on locomotives has been so successful that many important railroads have provided it for freight as well as passenger operations.

The following is a full and detailed description of the Pyle-National Electric Headlight Equipment. This equipment is composed of two principal parts; the combined engine and dynamo and arc lamp. Fig. 1 shows the recommended practice of application of the electric generator. Fig. 2 shows details of engine and dynamo, and Fig. 3 shows standard arc lamp.

The Engine.—The engine is known as the Pyle-Triple Expansion Steam Turbine, the speed of which is controlled automatically for variable steam pressure, and load by a sensitive governor of the centrifugal fly weight type, the speed of which is marked on the dynamo door plate, and refers to the speed of the machine when the arc lamp is not burning. The speed of the standard type "E" unit is 2,800 R. P. M.

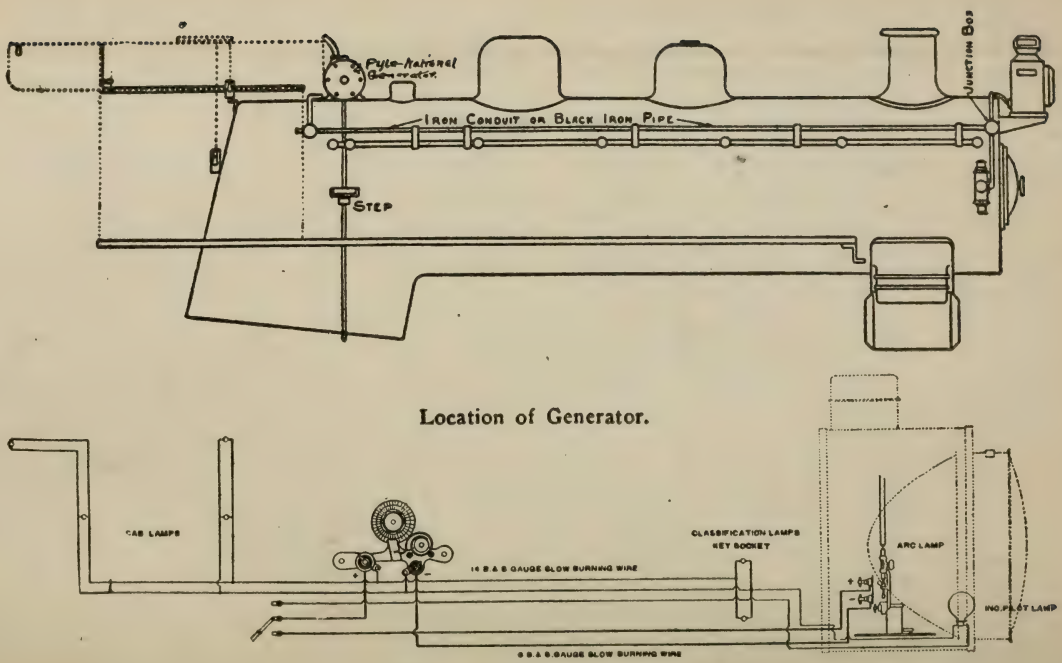

Fig. 1. Diagram of Wiring.

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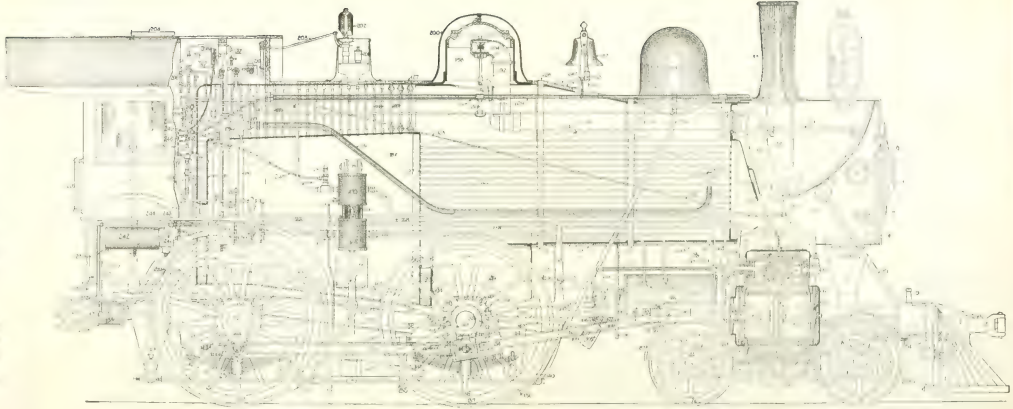
PLATE I.

DESCRIPTION OF THE LOCOMOTIVE, AS PER DIAGRAM HEREWITH.



THE AMERICAN TYPE LOCOMOTIVE. Prepared exclusively for Kirkman's "Science of Railways."

Particularizing the different parts of the locomotive and giving the names by which they are known to those connected with the Motive Power Department. It is at once a Chart and an Encyclopedia, each part of the locomotive being given a number so that it may be recognized and quickly referred to.

Due to steam conditions it is not always easy to obtain maximum speed when the locomotive is standing. Therefore, the better practice is to set the speed when the load of the arc lamp is not being carried, i. e., with the arc switched out and allowing 150 R. P. M. in addition to the speed shown on the door plate.

Thus, in taking a check on the speed, if the door plate indicates 2,800 R. P. M. instead of trying to obtain this speed with the load of the arc on the machine, switch out the arc lamp and, with the incandescent lamps burning note that the speed does not exceed that shown on the door plate more than 150 revolutions, which, in this case, would be 2,800 plus 150, making a total of 2,950, the highest number of revolutions permissible. If 2,400 R. P. M. was shown on the door plate the no-load speed should then not exceed 2,550 R. P. M.

The only exception to this rule is in checking the speed of new units, which have had less than one week's service. Do not permit their no-load speed to be in excess of the load-speed marked on the door plate of the dynamo.

Lubrication.—Lubrication, which is required only by the bearings, is accomplished through two oil cups in which a heavy oil should be used. To insure regular lubrication the oil cups should be examined each trip. If the equipment should be taken out of service for a considerable length of time introduce one-half pint of ordinary engine oil into turbine oil cup and revolve shaft a few times by hand. This will distribute the oil and prevent corrosion of parts.

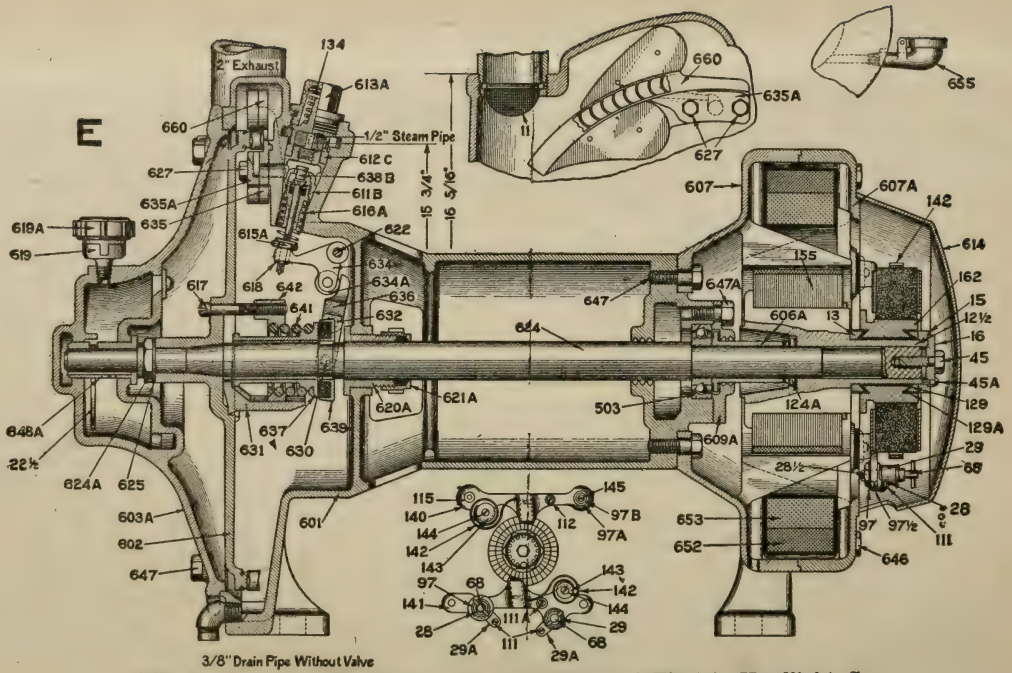


Fig. 2.—Generator Equipment "E," Pyle National Electric Headlight Co.

The Dynamo.—The dynamo is of the Bi-pole internally magnetized type, so perfect in its electrical balance that no sparking at the brushes should be seen. The armature, which is held in place on the shaft by a single screw, may easily be removed should occasion require. The brush holders are fixed; though the brushes may be removed or replaced without changing the tension of their springs.

The brushes should fit perfectly on the commutator; that is, the contour of the wearing surface of the brush should be the same as that of the commutator. This is accomplished by cutting a strip of sand-paper (not emery paper) about the width of the brushes. Place sand-paper strips between commutator and brush, then draw sand-paper from left to right until brush has proper bearings.

Names and Numbers of Parts. Fig. 2.

11	Exhaust Screen.....	115	Bushing .....
12-½	Armature Spider.....	124-A	Shaft Pin .....
13	Commutator Ring.....	129	Mica Taper Ring.....
15	Commutator Nut.....	129-A	Mica Band Ring.....
16	Outside Washer.....	130	Winding Ring.....
28	Binding Post, large hole with Nut.....	140	Top Brush Holder.....
		141	Bottom Brush Holder....
28-½	Binding Post Nut.....	142	Brush Spring .....
29	Binding Post, small hole with Nut	143	Brush Spring Adjuster...
		144	Brush Adjuster Screw,
29-A	Incandescent Terminal...	145	Brush Holder Screw,
45	Armature Lock Screw....	146	Top Brush Holder, complete .....
45-A	Small Lock Screw.....		
68	Binding Post Screw.....	147	Bottom Brush Holder, complete .....
97	Insulation Washers,		
97-A	Small Fibre Washer,	155	Armature .....
97-B	Brush Holder Iron Washer,	162	Commutator complete
		503	Ball Bearing .....
97-½	Fibre Bushing,	600	Turbine, complete .....
111	Binding Screw	601	Turbine Casing .....
111-A	Shunt Field Connecting Screw	602	Turbine Wheel .....
		603	Turbine Cover .....
112	Field Screw	604	Turbine Cover Cap.....

606-A Armature Sleeve .....
607 Rear Field Frame.....
607-A Front Field Frame.....
609-A Ball Bearing Cap.....
611-A Valve Cage .....
612-A Valve Seat .....
613-A Valve Cap .....
614 Dynamo Door .....
614-A Dynamo Name Plate.....
614-B Dynamo Door Pin.....
614-C Dynamo Door Latch.....
615-A Valve Adjusting Nut.....
616-A Governor Valve Spring...
617 Governor Adjusting Screw .....
618 Valve Lock Nut.....
619 Oil Cup .....
619-A Oil Cup Cover.....
620-A Turbine Case Bushing...
621-A Packing Gland .....
622 Governor Link Screw....
624 Shaft .....
624-A Wheel Retaining Nut....
625 Wheel Retaining Washer
627 Nozzle Screw .....
630 Anti-Friction Ring Holder Screw .....
631 Governor Weight .....
632 Governor Arm Screw.....
633-A Oil Cup, complete.....
634 Governor Link with Roller .....
634-A Governor Link Roller.....
635 Guide Passage Plate.....
635-A Steam Nozzle .....
636 Governor Arm .....
637 Governor Sleeve .....
638-A Governor Valve .....
639 Anti-Friction Ring Holder .....
641 Governor Spring .....
642 Governor Yoke .....
646 Field Frame Screw.....
647 Turbine Screw .....
647-A Ball Bearing Cap Screw
648 Turbine Bearing, complete .....
649 Oil Ring .....
650 Governor Valve and Cage, complete .....
651 Dynamo Field Coil, complete .....
652 Shunt Field Coil.....
653 Series Field Coil.....
660 Nozzle and Guide Passages, complete .....

The mica between the copper segments of the commutator should always be a trifle below the surface. The mica, being harder than the copper segments and the brushes, will not wear away as rapidly and, as a result, the mica will in time project above the surface of the commutator and produce sparking. For best results, the mica should be about 1/64" below the surface of the commutator bars.

A small, three-cornered file should be used in dressing down the mica. The edges of the commutator bars are roughened in the process of filing or cutting the mica, therefore, after the mica has been reduced the commutator must be cleaned up and the burrs removed with a strip of No. 0 sandpaper.

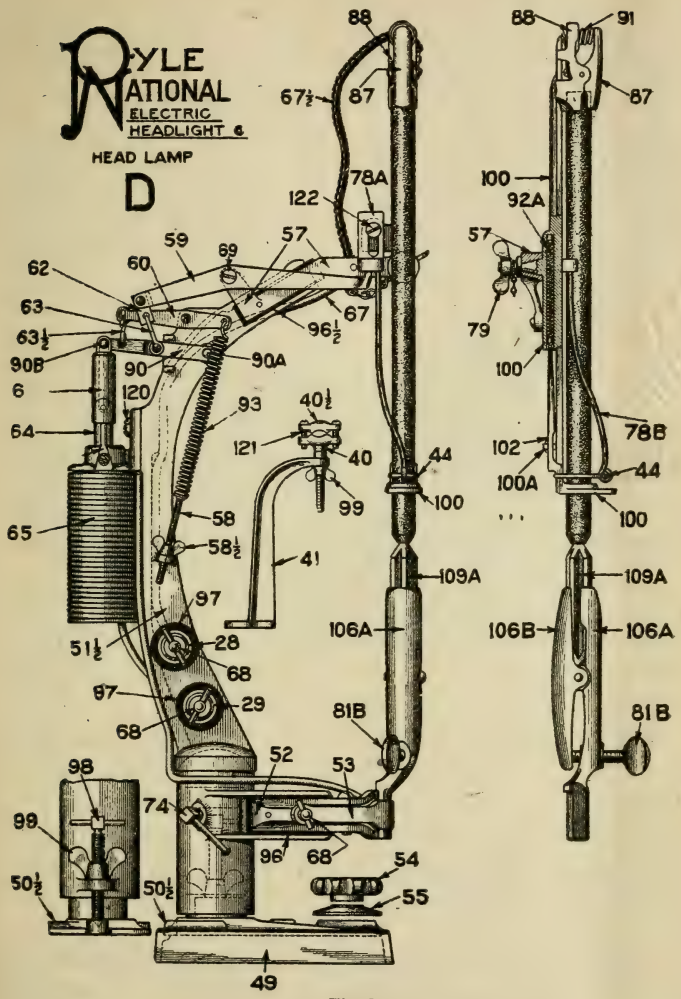


Fig. 3

Head Lamp "D." Pyle National Electric Headlight.

Names and Numbers of Parts. Fig. 3

28 Binding Post, large hole
28-A Washer 5-16
29 Binding Post, small hole
40 Reflector Clamp, bottom
40-½ Reflector Clamp, top
41 Reflector Support
44 Carbon Clutch
49 Extension Lamp Base
50-½ Lamp Base
51-½ Lamp Column
52 Large Bottom Clamp
53 Small Bottom Clamp
54 Hand Nut
55 Hand Nut Washer
57 Top Bracket
58 Tension Spring Screw
58-½ Tension Spring Screw Nut
59 Top Lever
60 Small Lever
61 Dash Pot, complete
62 Insulating Link
63 Solenoid Plunger Connecting Link
63-½ Solenoid Plunger Yoke Link
64 Solenoid Plunger
64-A Link, connecting Nos. 64 and 90
65 Solenoid
67 Top Positive Conductor
67-½ Beaded Conductor
67-½A Screw for Beaded Conductor
68 Binding Post Screw
69 Top Lever Screw
74 Set Screw
78-A Clutch Weight
78-B Clutch Weight Rod
79 Thumb Nut
79-A Chain and Link
81-B Thumb Screw
87 Carbon Clamp, male
88 Carbon Clamp, female
88-A Contact Brushes, set
90 Solenoid Plunger Yoke
90-A Solenoid Yoke Pivot Pin
90-C Solenoid Yoke Cotter Pin
90-C Spring Cotter
91 Carbon Holder Spring
92-A Clutch Spring
93 Tension Spring
93-A Tension Spring Screw and Thumb Nut, Complete
96 Bottom Clamp Insulation
96-½ Top Bracket Insulation
97 Insulating Washers (large)
97-A Insulating Washers (small)
97-½ Insulating Bushing
98 Vertical Adjusting Screw
99 Vertical Adjusting Screw Nut
100 Top Carbon Holder Slide
100-A Top Carbon Holder Stud
100-C Washer
102 Clutch Foot
106-A Lower Electrode Holder Shank
106-B Lower Electrode Clamp
106-C Electrode Holder Pin
109-A Lower Electrode
112-A No. 6 Tinned Iron Burrs,
115 Insulating Bushing
120 Solenoid Screw
121 Reflector Clamp Screw
122 Clutch Weight Shoulder Screw
132 Reflector Support, complete
145-A No. 3 Tinned Iron Burrs,
200-A Lower Electrode Holder, Complete
300 Upper Carbon Electrode Holder, Complete

MISCELLANEOUS SCREWS.

207 Connecting Nos. 67 and 57
208 Connecting Nos. 57 and 51½
209 Connecting Nos. 60 and 51½
210 Connecting Nos. 90 and 51½
211 Connecting Nos. 61 B and 65
212 Connecting Nos. 61 and 90
215 Connecting Nos. 88-A and 88,
157 Lamp Complete
197 Bottom Clamp, Complete
199 Carbon Contact Holder Complete, Comprising No. 87, 88, 91

The position of the brushes on the commutator is fixed. An even pressure of the brush upon the commutator is maintained by the tension of the

brush holder springs and once properly adjusted will remain fixed unless tampered with. To make the adjustment, as when unit is undergoing repairs of a general nature, remove the screw 144, when the adjuster, 143, may be turned to right or left as required. The flexible connector on brush insures perfect contact between brushes and brush holders.

The commutator is the vital part of any dynamo and will not run successfully if permitted to spark. Should the commutator become burnt or out-of-

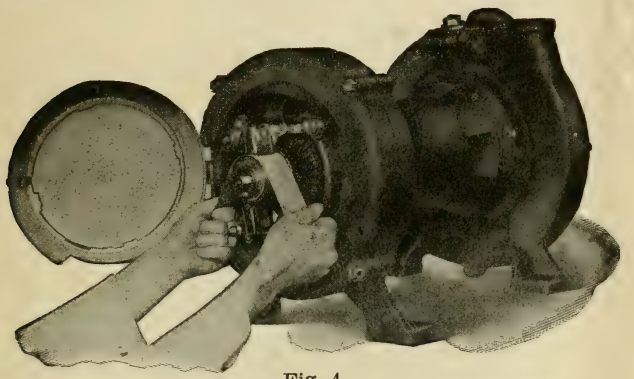


Fig. 4

round, the armature must be removed and the commutator trued up in a lathe. A sharp V-tool must be used and light high speed cuts taken in truing up. On removing from the lathe, burrs will be found projecting over the mica grooves. To prevent short-circuiting, the commutator burrs must all be removed with a small, three-cornered file, after which the commutator must be cleaned and polished with a strip of fine sand-paper (not emery paper). See Fig. 4.

The lamp.—The lamp is simple, durable and reliable. After a few trials it will be found an easy matter, even in the dark,—should circumstances require,—to trim the lamp. In putting in the carbon, it will be found much better to remove the car-

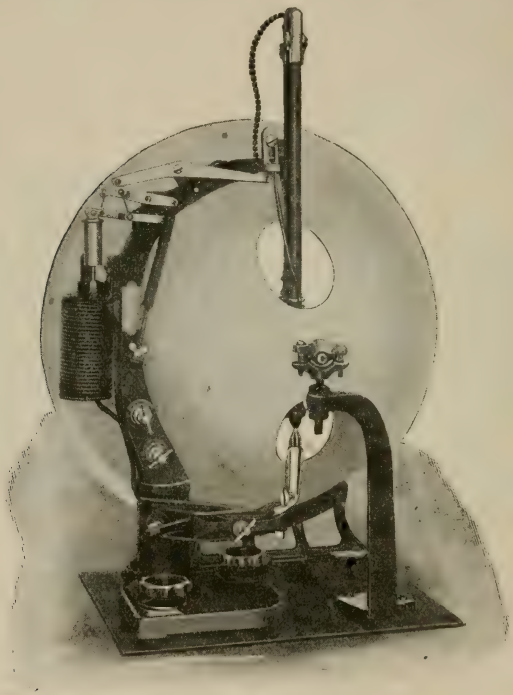


Fig. 5

bon clamp, 87 and 88, from the slide, 100. To clean the reflector remove the top guide, 100; first removing by unscrewing the winged thumb nut, 79, at the top of the upper arm of lamp frame. The guide, carbon and the holder may then be taken from the

lamp. After disconnecting from their binding posts the lead wires—always observing whether the end of one is doubled over so there will be no chance to connect them up wrong—the reflector on its slide may be pulled from the case.

The tension spring, 93, on the lamp is for one purpose only. Its function is to counterbalance the weight of the levers and also of the iron core, 64, in the solenoid; so that the clutch may release the carbon. The tension on the spring, 93, should be adjusted when there is no current passing through the lamp. The tension of this spring should be sufficient only to bring magnet yoke, 90, up against the stop lug on the lamp column, 51½.

If the tension spring is too loose the light will flash and go out, especially when the locomotive is at rest. If the tension spring is too tight the magnet may be unable to separate the carbons, causing a heavy current to pass through the windings. This will cause the solenoid to be heated to a very high temperature, destroying the insulation on the windings and resulting in a very poor light.

When the arc lamp is not burning the carbon must pass freely through the clutch, 44, and rest centrally upon the point of copper electrode.

The current must enter the lamp at positive binding post, 28 (binding post having large hole). From this point the current passes through a connecting wire to the top of the carbon holder, through flexible connector (pig tail), 67, (not shown in cut of lamp), and contact brushes, down through carbon and electrode connection on bracket, 52; through solenoid, 65, and out to bind-

ing post, 29, with the small hole. The magnet core, 64, is suspended at the end of the magnet yoke, 90. The current passing around the windings on the solenoid, 65, creates a downward pull on the iron core, 64, which, in turn, actuates lever, 59, on which rests clutch weights, 78-A; clutch rod, 78-B, and clutch, 44. The upward movement of this clutch separates the carbon from the electrode, and an electric arc, the source of the light, is formed between their points.

When starting, if the carbon and electrode are separated, even by a fraction of an inch, the light will not burn, though the dynamo may be running at full speed. This is because the circuits cannot be established until the points of the carbon and electrode are in actual contact. A deposit which prevents the carbon making contact with the electrode is sometimes found on the point of the copper. A deposit of scale also forms between the electrode and holder, 106, and unless electrode is removed from holder occasionally and this scale cleaned out, a light failure may result.

Most electric headlight troubles are traceable to improper adjustment of the lamp and if ordinary care is taken in making the adjustments noted below, much trouble may be avoided.

Magnet yoke, 90, may travel too far from the upper of the two small lugs on the lamp frame before the carbon and electrode are sufficiently separated to make the proper arc. When clutch, 44, begins to raise carbon the upper edge of magnet yoke, 90, should not be more than $\frac{1}{8}''$ below top stop lug. If the yoke, 90, travels too far from the top stop

lug, it is an indication that clutch, 44, has become worn, and same should be replaced with a new clutch. The proper position for the lamp levers when magnet yoke, 90, is up against top stop lug should be such that the clutch weight, 78-A, rests on the forward end of lever 59. Clutch rod should then be adjusted so clutch, 44, rests horizontal.

If the clutch rod, 78-B, is too short the carbon will stick in clutch, 44, causing lamp to go out. Clutch rod, 78-B, should be of sufficient length to hold clutch 44 at right angles to upper carbon holder slide 100.

If the light burns green the dynamo may be running too fast in which case the speed could be reduced. Until this condition can be properly attended to at the terminal the steam supply to the turbine should be throttled at the globe valve in the cab.

Another reason for the light burning green may be in the main wires from the dynamo to lamp having been connected up wrong. To prevent this happening, each of the two ends of the positive wire should be doubled over so as to make impossible their connection to the wrong binding post. The ends of the negative wire should be left plain for entering the small hole of the binding post 29.

To Focus Lamp.—1. Adjust back of reflector so front edge will be parallel with front edge of case.

2. Adjust lamp to have point of copper as near center of reflector as possible.

3. Have carbon in center of chimney hole in reflector.

4. Have locomotive on straight track and move lamp until you get best results on track. The light should be reflected in parallel rays.

To lower light on track, raise lamp. To raise light on track, lower lamp.

If your light throws any shadows it is not focused properly.

If light is focused properly and does not then strike center of track do not change focus, but shift entire case on baseboard.

Point of copper should be about one inch above top of holder, 106. If it is higher than this, there will be too much heat on clutch, 44.

The following is the approximate focal point of various size reflectors:

16″ x 8″	$2\frac{3}{8}$″
17½″ x 10½″	$1\frac{5}{8}$″
18″ x $8\frac{3}{4}$″	$2\frac{3}{16}$″
18″ x 9″	$2\frac{1}{4}$″
18″ x 12″	$1\frac{3}{4}$″
23″ x 14″	$2\frac{1}{8}$″

Note: Explanation of electrical terms, pertaining to the care of the Electric Headlight, will be found at the close of the entire chapter on this subject.

MODEL "D"
AMERICAN ELECTRIC HEADLIGHT

Model "D" American Electric Headlight consists of: Turbine-Generator, Arc Lamp, Case and Reflector and accessories for locomotive headlighting and field construction work.

GENERAL DATA OF TURBINE-GENERATOR

Length over all	27¼ in.
Width	27½ in.
Height	17 in.
Weight	240 lbs.
Speed	2800 R.P.M.
Voltage	30
Capacity	1 K.W.
Steam consumption per service hour	175 lbs.
Maximum steam pressure	250 lbs.
Necessary minimum steam pressure, full load	90 lbs.

GENERAL DATA OF ARC LAMP

Height over all	26¼ in.
Width	8½ in.
Weight	18 lbs.
Voltage	28
Amperes	30
Maximum unreflected candle power	1700

GENERAL DATA OF CASE AND REFLECTOR

Reflector Size	18 in. dia. by 10½ in. deep
Size of number glass	5¾ in. x 11¼ in.
Base	21 in. wide by 17½ in. deep
Height over all	31½ in.
Weight	90 lbs.

MAINTENANCE AND CARE OF MODEL D HEADLIGHT
GENERAL INSTRUCTIONS

Where trouble exists the cause of which is not at once apparent, the following procedure is recommended.

(1) Where arc lamp fails to burn, but cab lights burn satisfactorily:

Examine arc circuit connections in cab, to see that surfaces are clean, in good contact, and that screws are tight.

Examine contacts at lamp binding posts, to see they are secure, etc.

Lay carbon across lamp binding posts, and if no flash occurs, see paragraph No. 3. If there is a flash, proceed as follows:

Manipulate lamp mechanism by hand, to see that it works freely, and that carbon falls freely through the clutch ring.

Thoroughly clean copper electrode.

See that all current conducting surfaces of the lamp are clean, and that all wiring on the lamp is in good contact and condition.

(2) When cab lights fail to burn, but arc lamp burns satisfactorily:

Examine cab circuit fuse.

See that all cab circuit connections are in good order.

Examine cab circuit connections at the dynamo or fuse block.

Examine cab wiring to see if any wires are broken.

(3) If no flash occurs at arc lamp binding posts, when carbon is laid across them, but cab lights burn satisfactorily:

With wires in lamp binding posts secure, examine all arc circuit wiring between the dynamo, switch and arc lamp.

(4) When all lights fail to burn the steam valve being well open, the arc lamp switched in, and the boiler pressure at least one hundred pounds:

Note from the sound if turbine is getting steam, and is working up to speed. If not up to speed, see paragraph No. 5. If up to speed, proceed as follows:

Examine wiring connections for the cab circuit.

Examine arc circuit connections in the cab.

Lay carbon across dynamo binding posts and if flash occurs, examine the wiring circuits, and if necessary the arc lamp. See

paragraph No. 1. If no flash occurs, press brushes against the commutator at the same time.

See that brushes are in good contact.

If necessary clean commutator.

Examine all internal dynamo wiring connections to see that they are properly connected, and in good and secure contact. Especially note brush holder connections.

Examine dynamo in general.

(5) When arc and cab lights burn dim, the steam valve being well open, and the boiler pressure being at least 100 pounds:

Test for shorts and if any are found, see paragraph No. 6.

If no shorts exist, blow out steam strainer.

Test to see if shaft rotates freely.

Remove all plugs necessary to blow out all steam passages.

Disconnect valve rod, and test valve mechanism and if necessary test governor mechanism to see that it works freely.

Examine nozzle to see if stopped up.

Examine turbine in general.

(6) To locate short circuit.

Disconnect one wire at a time, always replacing same, if trouble is not cleaned before another wire is disconnected. Short circuits most frequently occur in cab wiring.

(7) When all lights burn dim, steam valve being well open, the boiler pressure being at least 100 pounds and turbine-generator is in good condition.

Test for grounds:

(8) When arc lamp burns dim, but cab lights burn satisfactorily:

Examine the lamp. See paragraph No. 1.

TURBINE-GENERATOR

Lubrication. A good grade of valve oil must be used wherever lubrication is necessary.

Oil in turbine end bearing oil reservoir must be replenished each trip, about two tablespoonsful being required per trip. To replenish oil close off steam valve, open side drain cock No. 93 and remove top hand plug No. 777, next pour valve oil in until it overflows through the side drain cock, then close same and replace top plug. It is important that top plug be replaced securely after each oiling operation as the oil reservoir must be air tight.

All rubbing surfaces of governor must be oiled each trip. An oil hole is provided in each side of governor, one for oiling ball-bearing and one for oiling shaft where governor cage works on same. About five drops of oil should be applied to each oil hole each trip.

Packing No. 197 in the shaft stuffing box should be oiled once a week. This is done by filling the oil cup No. 1922 which is mounted on the side of turbine.

A few drops of oil must be applied to the dynamo ball-bearing each trip. This can be done by use of oil cup No. 609.

Bronze Bearing. To remove bearing No. 757, take off cap No. 760, take out four cap screws No. 150 and remove bearing housing, complete, No. 756 from shaft. Then remove screw No. 762 which is at flange end of bearing and press bearing No. 757 from housing. In replacing bearing bushing the bearing housing No. 756 should first be inverted to insure that oil ring No. 56, does not interfere.

Dynamo Ball-Bearing. To remove dynamo ball-bearing take off nuts No. 1053, withdraw end cap No. 1043, and back off shaft nut No. 1045, which has a right-hand thread. Next remove cap screw No. 150, and withdraw end bracket No. 1041, with ball-bearing and sleeve No. 210. Dirt and water are very destructive to ball-bearings and care must be taken in handling these bearings that they are kept clean and well oiled.

Governor Ball-Bearing. This bearing is carefully fitted into housing and on to cage by special tools at the factory and is not furnished except as a part of the bearing cage and housing complete No. 599. This bearing must be kept clean and well oiled, about five drops of oil per trip being necessary.

Wheel. To remove wheel take out cap screws No. 150 which hold end cover No. 652 in place, and take off the end cover. Next block the governor to prevent the shaft from turning and back off shaft nut No. 1036. The wheel can then be removed by applying equal force at two points of the outer edge but directly opposite, or by use of two set screws applied to two tapped holes in wheel hub.

Nozzle. To remove nozzle take off end cover No. 652 with bearing housing No. 756. Next remove screws No. 1066.

Steam Strainer must occasionally be blown out but most particularly on new installations and after locomotive has been in the shop.

Valve. To ascertain if valve is properly operating, turn off steam, disconnect valve rod yoke end No. 300, and manipulate valve arm No. 665 by hand. If mechanism does not work freely, remove valve cap No. 659, and inspect valve. If necessary clean plunger No. 653. To clean valve passages, remove blow-out plugs, turn on steam and thoroughly blow out any scale or sediment.

To take valve apart, disconnect connecting rod No. 298, loosen set screw No. 449, and remove rocker arm No. 665. Take off cap No. 659 and packing nut No. 763. Remove valve shaft complete No. 664 with valve rocker arm. This may be done by depressing valve plunger No. 653 and taking the valve shaft No. 664 out through the top of the valve housing. Insert pliers and grasp valve plunger No. 653 by the head and withdraw. Washer No. 655 and spring No. 674 may now be removed. If necessary to take out valve sleeve No. 654, insert a flat piece of metal into the slots in the top of the sleeve and unscrew. When replacing valve sleeve apply graphite and oil to threaded portion. In assembling valve, the plunger automatically positions itself in the sleeve, but care must be exercised to see that sleeve is screwed as far down into housing as it will go.

Valve-Governor Linkage. In connecting up connecting rod No. 298 back off yoke No. 300 so that rod is longest possible and yet have pin holes in yoke No. 300 line up with hole in governor yoke No. 469, in such a way that there is no lost motion in linkage.

Governor Yoke. It is very important that governor yoke No. 469, does not bind in any position of operation and the free action of the governor yoke can be tested best when machine is in operation, but running without any load.

Governor. To ascertain if governor is working properly, turn off steam, disconnect connecting rod yoke end No. 300, and manipulate the yoke No. 469 back and forth. If any binding occurs relieve same.

Generator speed should be about 2800 R. P. M. To increase speed, turn nut No. 17 to the right, that is, screw up to shorten spring. To decrease speed, turn nut No. 17 to the left, that is, unscrew the nut to lengthen spring. One quarter turn of the nut changes the speed of generator about one hundred revolutions. Do not fail to tighten lock nut No. 17.

To take the speed of dynamo, remove plug No. 1044 and insert indicator in the end of shaft. Always replace this plug to exclude dirt from bearing.

To take governor apart remove pins No. 22 and thus release weights No. 19. Next straighten ears on spring plate No. 21 and remove the plate. Spring No. 18 may now be withdrawn.

Do not attempt to take bearing from bearing cage and housing for same. These are furnished as a whole part No. 599, and never separately.

Armature and Commutator. It is very important that the armature and the commutator run true. This is especially so of the commutator, as it may be permanently injured otherwise. Mica between the commutator bars should be kept filed down evenly below the surface of the bars to prevent jumping of brushes from which sparking results. To file down mica remove armature from dynamo, use a small triangular file, being careful not to scratch the commutator bars. Do not reduce mica more than 1-64 inch below surface. Remove all burrs, using fine sandpaper No. 00. (Never use emery cloth.)

If the surface of the commutator becomes greasy or dirty, clean with a piece of waste dampened with gasoline, rubbing lengthwise with the bars as the shaft is revolved slowly by hand.

If the surface of the commutator becomes roughened, smooth with a piece of No. 00 sandpaper (never use emery cloth) cut the proper width and held by the ends against the commutator while the latter revolves at high speed.

If commutator becomes burnt, is out of round or has a high bar, it should immediately be resurfaced in the lathe, using a V-nose tool and taking light cuts at high speed. After resurfacing, file down the mica, using a small three-cornered file, and remove all burrs, then polish the commutator with fine sandpaper No. 00 (never use emery cloth), when running at high speed in the lathe.

Brushes should fit the commutator surface snugly, or sparking is liable to occur.

To remove armature. Loosen field connections at brush holders and draw brushes out of holders. Remove nuts No. 1053, and end cap No. 1043. Take off shaft nut No. 1045 (which has a right-hand thread) blocking shaft at governor to prevent turning. Remove cap screws No. 150, and end bracket with ball-bearing can

be withdrawn. In handling end bracket it is not necessary to remove ball-bearing. The armature can then be drawn off shaft.

In replacing armature see that it sets home against the shoulder on the shaft and that pin No. 780 in shaft has engaged slot in spider. Care should be taken to replace armature end bracket in just the reverse order of removal. Do not judge the position of shaft and its freedom to turn until all nuts and bolts are drawn up tightly.

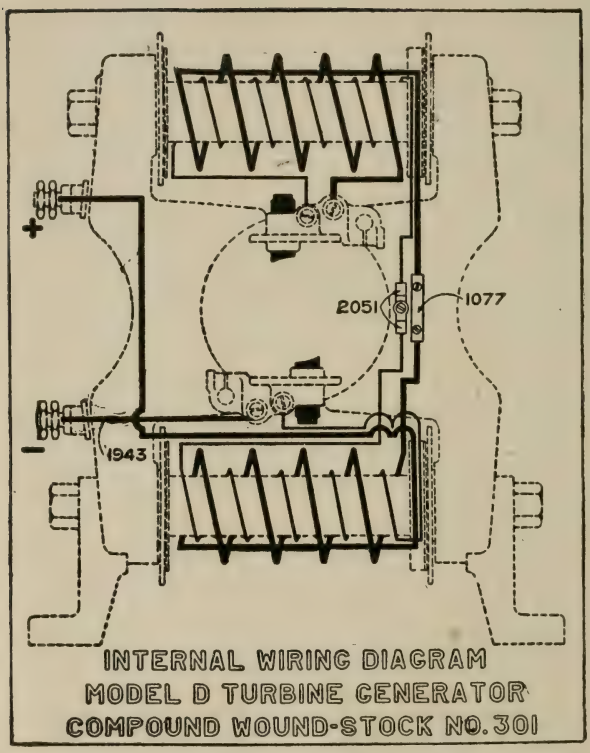
Where it is necessary to replace commutator or completely rewind armature, the commutator and spider may be forced out of armature after taking off spring ring No. 409. Never touch commutator nut No. 1022.

Brushes and Brush Springs. Brushes will last under ordinary conditions about one year and are easily renewed. When fitting a new brush, slip same in holder No. 1042, and under spring No. 43. Insert a strip of No. 00 sandpaper, (never use emery cloth), between the brush and the commutator with the rough side to the brush and pull back and forth until brush surface has proper curvature.

The brush spring should have just enough tension to prevent sparking, but not enough to cause excessive wear or undue heat. To adjust tension of brush spring No. 43, slightly back off screw No. 1055 and manipulate screw No. 420 as necessary. Then tighten screw No. 1055. Once adjusted properly the brush springs require no further attention.

Field Coils. The correct position and electrical connections of the field coils can be noted from Fig. 1. Bolts No. 474 and 460 which hold fields in place should be drawn up tight otherwise dynamo will not generate properly. Field covers must always be replaced as these afford protection against dampness and dirt.

Internal Wiring. As shown in Fig. 1 the inside leads (both series and shunt wires), from the top field connect respectively to the outside leads of the bottom field. The outside lead of top shunt coil connects to top brush holder and the inside lead of bottom shunt coil connects to bottom brush holder. The inside lead of bottom field connects to top binding post, and the bottom binding post is connected to the bottom brush holder by means of a jumper.


+
2051
1077
1943
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INTERNAL WIRING DIAGRAM
MODEL D TURBINE GENERATOR
COMPOUND WOUND-STOCK NO. 301

Fig. 1

ARC LAMP

It is very important that the arc lamp be kept in good working condition and careful inspection at frequent intervals should be

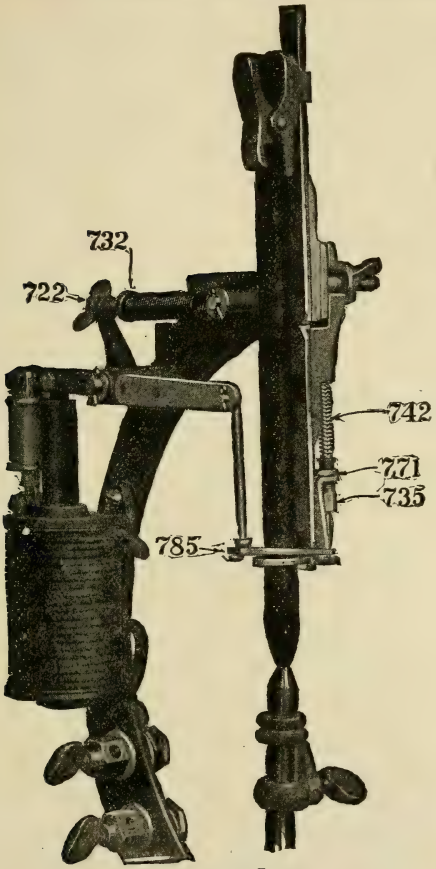

Fig. 2—Arc Lamp

made to see that the lamp mechanism works freely, that current carrying surfaces are clean, that no grounds exist, that arc is in proper focus and that all screws and connections are tight.

To adjust clutch mechanism insert a carbon in lamp so that it rests squarely on copper electrode. Also see that carbon and copper electrodes are in line.

With no current flowing through the lamp, unscrew jam nut No. 771 and back off screw No. 735 until there is no pressure exerted by the spring No. 742. Loosen thumb nut No. 722 and adjust tension of spring No. 732 such that the clutch ring No. 785 is at a slight angle but not sufficient to prevent the free movement of the carbon when raised and lowered by hand. That is, the clutch should not grip the carbon. Thumb nut No. 722 should now be tightened.

The current should now be turned on and the lamp carbon will have a tendency to jump. Screw No. 735 should next be tightened up to increase the pressure of spring No. 742, just sufficient to prevent jumping. Jam nut No. 771 must now be tightened.

There should be a slight flickering of the light when locomotive is stationary, this flickering disappearing when locomotive is in motion. A very slight hissing at the arc and absence of green color to the light is an indication that the speed of the dynamo is correct.

The clutch mechanism should be adjusted when the voltage at the arc is approximately 28, and the current consumed by arc is about 30 amperes. By increasing tension of the lamp springs, the current consumption is increased. It is advisable, therefore, to keep all springs as loose as consistent with satisfactory performance of the lamp.

The function of spring No. 732 is to always return the lever to proper starting position so as to cause the clutch ring No. 785 to release the carbon allowing it to drop and re-establish the arc which has been broken due to burning away of carbon or to turning off of current. If this spring No. 732 is too tight excessive current is used, if too loose, clutch ring No. 785 will not release the carbon to again establish the arc.

The function of spring No. 742 is to prevent carbon from "jumping" which occurs if this spring is too loose. Also this spring should press down on foot No. 735 sufficient to cause clutch ring No. 785 to properly grip and prevent carbon from "crawling" due to vibration when locomotive is running.

If light burns bright when engine is stationary, but dims when

engine is in motion, and inspection shows that all wires are tight, in good order and insulated, the lamp spring No. 742 must be tightened.

If light burns satisfactorily when engine is in motion, but goes out when locomotive is stationary, the carbon catches in clutch ring, and spring No. 732 must be tightened.

Carbons for the lamp should be of good quality, free from hard spots, accurately gauged to size and should have no seams or rough spots as these would prevent proper feeding.

To insert new carbon in lamp, remove clamp No. 226 from guide and transfer it to the new carbon. Thrust pointed end of carbon through hole in reflector, straighten up and raise sufficient to insert it in clutch ring No. 785, at the same time sliding clamp on to guide No. 713.

The carbon must strike squarely on the lower electrode which should be lined up by bending the lower holder No. 304 slightly.

The tip of the copper electrode No. 310, should be ¼ inch in diameter and should stand one inch above the top of the electrode holder No. 304. If higher or lower, heat from the arc may injure clutch or lower holder. In case the copper electrode is burned or melted on one end, it may be filed to the proper shape or the reverse end used. The electrode is 9-16 inch in diameter and carries off heat and produces a much better light than a ½-inch electrode which should not be used except in an emergency.

When putting in a new carbon, care must be taken to see that it works freely. If the carbon catches in the clutch ring, examine to see if it is perfectly straight and smooth.

A scale deposit sometimes remains on the tip of the copper electrode and prevents the carbon from coming in contact with the copper. This will prevent the passage of current and the electrode should be cleaned of scale each trip, a file being used for this purpose.

Also a scale gradually forms all over the outer surface of the copper electrode, due to the heat and this may prevent passage of current. The copper electrode No. 310 should frequently be removed from holder No. 304, and cleaned of all scale by use of a file.

If the copper electrode fuses, the current or voltage may be too high, due to excessive speed of the dynamo and the steam must be throttled in the cab until governor can be examined.

The thumb screw No. 223 is for the purpose of holding the electrode in place and securing the proper electrical contact. It is essential that this screw be tight at all times, since looseness may prevent light from picking up.

The lower electrode holder No. 304, must be securely clamped since looseness and vibration will incline the electrode thereby allowing the carbon to slip down along the side of the copper electrode No. 310, causing a dim light and throwing a heavy current on the dynamo and lamp coils.

To Focus Arc Lamp. If best results are to be obtained the arc lamp must be kept in proper position of focus. Fig. 3, shows arc lamp mounted in reflector.

Adjust the reflector so that it stands square in the case. Position the arc lamp on the reflector base so that the lamp frame No. 616 and the back edge of the lamp base No. 229, are parallel with the back edge of the reflector base plate. Adjust the lamp frame so that point of copper electrode No. 310 is as near the center of the reflector as possible. Position the lamp so that the carbon lines up centrally in holes in reflector.

With locomotive on a straight track turn on the current and perfect the position of the lamp so that reflected light is in parallel rays which form a well defined beam of light. Tighten hand wheels No. 341, and all other screws and connections.

With the reflector properly set in the case and the arc lamp properly focused in the reflector, adjust position of the case on the boiler to throw beam of light down the center of and parallel to the track. The arc should never be thrown out of focus to line the beam down the track. This must be accomplished by properly shifting the case and reflector.

If the arc light throws shadows or the rays are not parallel, thus failing to produce a well defined beam the arc is not in proper focus and will be very inefficient. On a clear, dark night with little smoke or steam to intercept the beam, an object the size of a man in the center of the track should be clearly defined at a distance of 3000 feet. This is only possible, however, with everything in proper condition and especially when reflector is bright and clean.

The copper electrode No. 310, will gradually scale away thus throwing arc out of focus. For this reason holder No. 304 should frequently be removed and position of copper electrode point adjusted to one inch above holder frame.

Improper focusing of the lamp often causes front glass to break, especially glass that is of poor quality, thin or flat. Do not lock glass too tightly in the case or cement it in place. This prevents

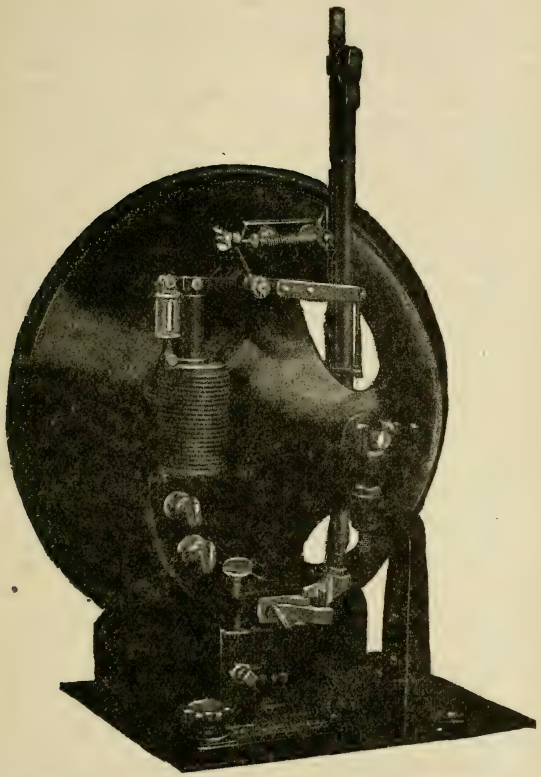

Fig. 3. Rear of Reflector Showing Arc Lamp in Position

expansion due to heat. A smoky or dirty front glass will seriously retard the beam of light.

In polishing reflector surface rub back and forth but never in a circular direction. It is recommended that a thin paste made of

lamp black and oil be used for polishing. This should be well rubbed on after which it should be removed with a piece of waste. Finally polish, using dry lamp black and clean white waste which will produce a fine lustre. This method insures long life to the plating. It is very important that reflector be kept clean.

When putting reflector or lamp in or taking out of the case, always remove upper half of carbon guide bar No. 292 by backing off thumb nut No. 393.

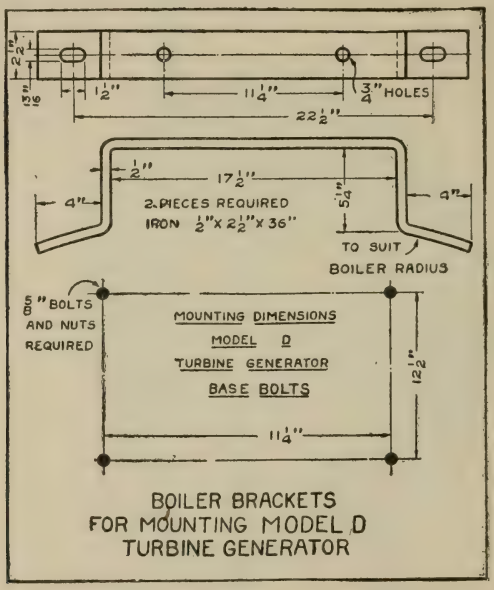

Fig. 4

INSTALLATION OF TURBINE-GENERATOR. It is recommended that turbine generator be mounted on the boiler between the steam and sand domes or directly in front of the cab. This location gives short steam connections and the best protection to the machine.

Brackets (dimensions of which are given in Fig. 4) should be fitted to the boiler and holes laid off for ¾-inch studs in the latter. Care must be taken to see that the bracket feet do not strike staybolt heads.

A ¼-inch iron plate 18 inches square can be used as a platform for mounting turbine generator if it is impossible to locate brackets so that ¾-inch holes line up with base bolt holes in turbine and dynamo feet.

The dynamo end of the machine may be placed either on the right or lefthand side of the boiler. The righthand installation is the most desirable as the wiring is shortened and the generator is more accessible to the engineer for inspection and oiling. By this installation, the steam end of the turbine generator is away from the engineer, thereby eliminating the danger of clouding the engineer's vision should any steam leaks occur.

So install the machine that it stands flat on the brackets or plate when they are bolted to the boiler. If necessary use washers at low points, otherwise in bolting down machine it will be drawn out of line and shaft is liable to bind.

Run a ½-inch pipe from fountain to turbine, placing a ½-inch valve in the most accessible place for the engineer. Do not use a valve with composition seat, as this seat wears away and particles may be transferred into the turbine valve.

The exhaust pipe is two inch (and never less) and should be carried back over front edge of the cab roof. It should have as few bends and be as short as possible to lessen back pressure. After cutting exhaust pipe to the right length, remove all burrs to lessen whistling noise due to exhaust steam.

Run a ⅜-inch iron drain pipe from the turbine case to a point well below the running board. This drain pipe must not have a valve of any kind and it is to be left open at all times. A union should be installed on this drain pipe near the turbine cover for convenience in dismounting cover or turbine-generator.

INSTALLATION OF ARC LAMP. If the case and reflector is not fitted for arc lamp, remove oil fount, burner and stand. Apply reflector support No. 1913 using three 5-16-inch bolts and riveting on the top. The front of the reflector must now be adjusted so that it stands perpendicular to the base. An adjustment on bracket No. 1913 is provided for this purpose. Set lamp in the reflector with the tip of copper electrode in the center of the same. The

following is the distance that this point should stand away from the back of the reflector for a pproximate focus:

18 in. dia. by 8¾ in. deep	2 3/16	in.
18 in. dia. by 9 in. deep	2¼	in.
18 in. dia. by 10½ in. deep	1⅜	in.
18 in. dia. by 12 in. deep	1¾	in.

To get exact focus see "To Focus Arc Lamp."

When lamp is properly located, mark two points on reflector base at the center of the two rectangular openings in lamp base No. 229. Drill and tap the reflector base for ⅜-inch studs, No. 340. Use washers No. 278 and hand wheels No. 341, furnished with the equipment to bolt down lamp. The illustration Fig. 3 shows lamp properly installed in reflector. Remove upper half carbon guide bar No. 292 and reflector may be slipped into case.

The current should enter the lamp at the top binding post No. 627, which has large hole to receive doubled back end of positive lead wire, the other end of which is connected through the switch to top binding post on dynamo.

There must be practically no play of reflector base plate in the guides. This would allow severe vibration and prevent proper focusing and operation of the lamp. If vibration occurs, properly wedge to overcome same. Having slipped reflector with lamp into case, replace guide No. 292, insert carbon in clamp No. 226, slip carbon through clutch ring at the same time sliding clamp on to guide.

Case may be applied to top of boiler or in center of front-end door. If mounted on the front door it must be strongly braced to avoid sever vibration. Care must be exercised to insure that case is straight with boiler and that the front is vertical with track. It will be impossible to obtain proper results unless these conditions exist.

WIRING. It is recommended that only slow burning, weather-proof wire be used for this work. It is preferable to use conduit for protecting the wires especially those on the outside of the cab and along the boiler, but the hand rail may be used for this purpose if the proper precautions are taken. The disadvantage of using the hand rail is the inconvenience and expense caused every time the hand rail is removed. Ends of all pipe must be reamed to re-

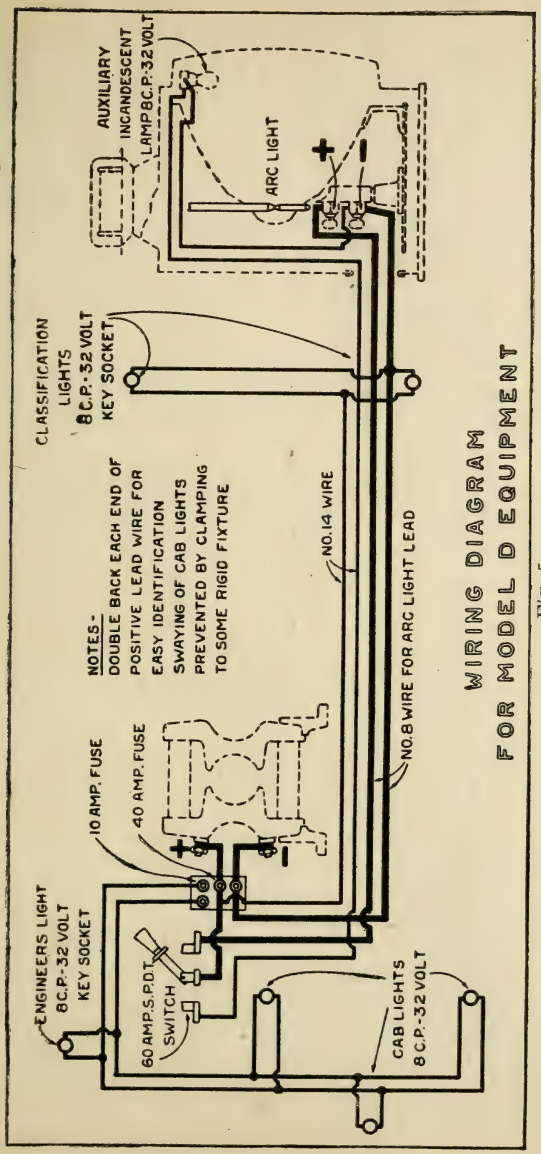
AUXILIARY INCANDESCENT LAMP 8 C.P.-32 VOLT
ARC LIGHT
+
-
CLASSIFICATION LIGHTS 8 C.P.-32 VOLT KEY SOCKET
NOTES-
DOUBLE BACK EACH END OF POSITIVE LEAD WIRE FOR EASY IDENTIFICATION
SWAYING OF CAB LIGHTS PREVENTED BY CLAMPING TO SOME RIGID FIXTURE
NO.14 WIRE
NO.8 WIRE FOR ARC LIGHT LEAD
10 AMP. FUSE
40 AMP. FUSE
ENGINEERS LIGHT 8 C.P.-32 VOLT KEY SOCKET
60 AMP. S.P.D.T. SWITCH
CAB LIGHTS 8 C.P.-32 VOLT
WIRING DIAGRAM
FOR MODEL D EQUIPMENT

Fig. 5

move burrs before inserting wires. If conduit is used it will be found more convenient to insert wires first, then bend to proper shape and lastly clamp in place. Before drawing wires, remove the insulation from each end of one of the large wires, also one of the small wires. This will identify wires without the necessity of testing out. Do not cut wires to the exact length required, but leave about two feet at each end. Wherever wires are exposed they should be bound together with tape and so installed that they will not lie on the boiler, pipes or other metallic parts.

Any reasonable number of incandescent lamps can be mounted in the cab or around the engine. Three in the cab and one over the deck are recommended.

It is preferable to use conduit or moulding in the cab. Wherever wires are exposed they should be held by cleats spaced not more than 12 inches and securely attached to the roof of the cab with screws.

Drop wires to gauges, lubricator, etc., should be the same kind of wire as main cab wires. Never use lamp cord or rubber covered wire for this purpose. Do not attach these wires to any metal fixtures, but brace lamps at sockets or reflectors. Sockets should be bushed where wires enter them unless pipe is used for protection. All drops should be securely soldered and taped where attached to main cab wires.

Wires to switch and fuse block should be cut at least four inches longer than necessary and coiled. This will prevent them from working loose under screws. If light is installed for engineer, a key wall socket should be used and light should be located above and just back of engineer's position. It is important that switch furnished with equipment be used. The latter is designed especially for this service and should be installed above and slightly in front of engineer's seat box.

Where classification lights are equipped, key sockets should be used. These lights should not be controlled from the cab.

It is very important to install an auxiliary low power lamp in front of the reflector. This light should be controlled from the cab by means of the same switch that controls the arc lamp (see wiring diagram, Fig. 5). This pilot light can be used in place of the arc lamp when the rules of the railroad require, under certain conditions, a less powerful headlight than the electric arc, for example:

When passing certain trains.

When on certain sidetracks.

When entering train sheds at large terminals.

When running through switch yards, etc.

This light is also very useful when examining or trimming the arc lamp.

When necessary to have all lights in case and reflector out this can be accomplished by withdrawing switch blade from all contact fingers.

By reference to wiring diagram it will be possible to install all wiring in the easiest and most direct manner. It is recommended that a standard wiring diagram be used for all engines. This will facilitate the work in installing and clearing trouble.

After all wiring is installed it should be carefully tested for short circuits and grounds. The short circuits will indicate themselves by throwing a heavy current on the dynamo when it is started up.

Grounds may be detected by rubbing the end of one lead wire at a time on some metallic part of the boiler. A flash will indicate a ground in the opposite wire.

IMPORTANT

All steam pipes should be blown out before connected to turbine. After steam has first been turned on for a few moments strainer should be cleaned. Machines are shipped without oil; do not attempt to run without complete oiling. Valve oil only should be used and daily applications must be made to turbine-generator. Never oil any parts of lamp. Wiring must be installed carefully and frequently inspected. The voltage is low and no injury can occur in handling the equipment. When focusing light be sure that no part of the lamp touches the reflector. A considerable change in color or intensity of the light indicates trouble; do not ignore this sign; troubles must be cleared immediately or serious damage to the equipment may result. Never change the adjustment of the governor unless absolutely necessary; this is set at proper speed before the machine leaves the factory. Lamp should be inspected and cleaned every day or trip; this is very necessary; it will eliminate road trouble and reduce maintenance cost. A green arc indicates reversed wires at the lamp or too high speed of the dynamo; try throttling steam in the cab; if this does not

cure, reverse wires at the lamp. If light burns dim, try the action of lamp clutch by pressing on lever No. 772 at the dash-pot; this must work freely. If light goes out when locomotive is stationary, the carbon does not slide freely on guide or in clutch; tighten spring No. 732. If light goes out suddenly when engine is in motion, it is most probable that a wire is loose or carbon is burned out; the latter should last about eight hours. All current carrying surfaces, especially the copper brushes on carbon clamp and the face of guide bar must be kept bright and clean, No. 00 sandpaper being used for this purpose. If light fails to pick up and wires are secure, place a carbon across binding posts No. 619 and 620; this will usually cause light to burn; if there is a flash, but light does not pick up, there is trouble in the lamp; if no flash look to the dynamo and place carbon across binding posts; if flash occurs, trouble may be with wiring. Copper electrodes are nine-sixteenths in diameter; never use half-inch copper with these lamps unless in an emergency. The lamp will burn when front glass to case is out, but the carbon will be consumed considerably quicker. Commutator sparking is very destructive and any trouble which causes sparking must be cured at once. Equipment should be tested at least once a week for grounds and if any are found, should be cleared before the light is again put into service; keep all screws and nuts tight. When renewing any electrical parts take care to get fibre washers or plates in their proper position. In winter it is recommended that throttle valve be allowed to leak just a slight amount of steam when dynamo is not in service.

Parts List for Model D Turbine Generator

Part Number	Name of Part
17	Governor adjusting nut.
18	Governor spring.
19	Governor weight.
20	Governor head.
21	Governor spring plate.
22	Pin for governor weight.
42	Top hinge hook for end door.
43	Spring for commutator brush.
56	Oil ring for main bearing bushing.
62	End door latch finger (see No. 318).
63	Spring for end door latch.
67	Base for end door latch (see No. 318).
78	Cotter pin for governor—end door hinge hooks—brush spring adjuster.
93	Pet cock for main bearing oil well.
127	Pin for end door latch (see No. 318).
128	Washer for brush holder binding screw.
132	Cap screw for turbine bearing housing cover.
141	Screw for turbine bearing housing cover.
150	Cap screw for turbine case cover, turbine case—connecting case—dynamo end bracket.
160	Screw for field cover.
185	Insulation for field coil.
190	Washer for binding post cap screw —brush holder stud.
197	Packing for main shaft.
198	Wire for armature.
200	Pin for top door hinge.
205	End filler for field coils.
206	Insulation washers for field.
207	End metal disc for bottom field coil.
208	End metal disc for top field coil.
209	Core for field coils.
210	Ball bearing and sleeve, complete for dynamo.
217	Brush holder, complete.
227	Washer for chain rivet.
232	Pole shoe (left-hand).
236	Pole shoe (right-hand).
259	Chain and ring complete for top door—turbine bearing housing cover plug—dynamo end bracket cap plug.
261	Washer for connecting case cap screws—dynamo end bracket cap screws.
262	Turbine case.
294	Pin for connecting rod yoke end.
298	Connecting rod complete (without No. 300).
300	Yoke end for valve connecting rod.
301	Turbine-generator complete (compound wound).
318	Latch complete for dynamo door.
322	Plug for main bearing oil well.
339	Pipe for steam strainer box.
343	Screen for steam strainer.
352	Steam strainer, complete.
381	Washer for governor yoke block.
396	Armature lamination with windings (see No. 403).
399	Commutator and spider only, complete (see No. 403).
403	Armature and commutator, complete.
408	Clamp for armature laminations.
409	Spring for armature clamp.
420	Brush spring adjuster.
438	Stud for top door.
441	Rivet for chain.
449	Cap screw for valve rocker arm.
454	Wire for shunt field winding.
458	Dynamo foot.
460	Cap screw for top field coil.
462	Binding post, complete.
463	Wire for series field winding.
469	Governor yoke.
470	Slide block for governor yoke.
474	Cap screw for bottom field coil.
477	Upper half cover for bottom field coil.
478	Lower half cover for bottom field coil.
486	Screw for end door latch.
497	Steam nozzle, complete.

Part Number	Name of Part
511	Bottom hinge hook for dynamo door
529	Nut for governor yoke pivot pin.
531	Pivot pin for governor yoke.
541	Ball bearing for governor (not furnished separate, see No. 599).
542	Cage for governor (not furnished separate, see No. 599).
543	Housing for governor bearing (not furnished separate, see No. 599).
556	Cap for steam strainer box.
590	Packing for valve shaft.
599	Bearing, cage and housing complete for governor.
605	Governor, complete.
606	Pin for governor head.
609	Oil cup for dynamo ball bearing.
617	Nut for binding post.
632	Slot filler for armature.
633	Cover for top field coil.
634	Top field coil, complete.
635	Bottom field coil, complete.
651	Connecting case.
652	Cover for turbine case.
653	Valve plunger.
654	Valve sleeve.
655	Washer for valve spring.
658	Stuffing box gland for main shaft.
659	Top cap for valve box.
660	Bearing cap for valve shaft.
663	Valve roller.
664	Valve shaft, complete.
665	Rocker arm for valve shaft.
669	Top door.
671	Thumb nut for top door.
674	Valve spring.
677	½-inch pipe plug for turbine case.
678	⅜-inch pipe plug for steam stranier
680	Exhaust screen
693	Bushing for brush holder stud.
724	Washer for binding post.
747	Screw for valve roller.
751	Bushing for binding post cap screw.
752	Insulation for binding post cap screw.
755	Cap screw for binding post.
756	Turbine bearing housing.
757	Turbine bearing bushing.
758	Cover for turbine bearing housing.
760	End cap for turbine bearing housing.
762	Screw for turbine bearing bushing.
763	Stuffing box for valve shaft.
764	Gland nut for valve shaft stuffing box.
775	Gasket for turbine bearing housing cover.
777	Plug for turbine bearing housing cover.
780	Shaft pin for armature spider.
788	Steam strainer box.
1002	Turbine wheel, complete.
1018	Taper insulation ring for commutator (see No. 1039).
1020	Band insulation ring for commutator (see No. 1039).
1021	Washer for commutator nut (see No. 399).
1022	Clamp nut for commutator (see No. 399).
1023	Core insulating for commutator (see No. 399).
1025	Clamp ring for commutator (see No. 399).
1028	Segment insulation for commutator (see No. 399).
1035	Washer for wheel hub.
1036	Nut for wheel hub.
1038	Spider for armature.
1039	Commutator only (not including spider).
1040	Commutator segment (in rough) (see No. 399).
1041	Dynamo end bracket.
1042	Brush holder frame.
1043	Cap for dynamo end bracket.
1044	Plug for dynamo end bracket cap.
1045	Nut for shaft at dynamo end.
1047	Insulation for brush holder.
1048	Stud for brush holder.
1049	Stud for dynamo end bracket cap.
1051	Ball bearing (not furnished separate, see No. 210).
1053	Nut for dynamo end bracket cap stud.
1054	Nut for brush holder stud.
1055	Screw for brush spring adjuster.

Part Number	Name of Part
1056	Screw for brush holder binding post.
1058	Commutator brush with pig tail.
1059	Shaft.
1066	Screw for steam nozzle.
1070	Screw for stationary bucket.
1071	Stationary bucket, complete.
1074	Dynamo door.
1077	Wire connector for field series wire.
1918	Long nipple for shaft stuffing box oil pipe.
1919	Short nipple for shaft stuffing box oil pipe.
1920	Elbow for shaft stuffing box oil pipe.
1921	Coupling for shaft stuffing box oil pipe.
1922	Oil cup for shaft stuffing box.
1943	Series wire jumper.
1999	Shunt lead terminals.
2029	Water hood for binding post.
2031	Binding post base and stud, complete.
2051	Terminal complete for shunt field lead.

Parts List for Model D Arc Lamp

Part Number	Name of Part
82	Finger for copper electrode holder clamp.
88	Cotter pin.
101	Finger for carbon clamp.
108	Thumb screw for frame adjustment.
115	Spring for carbon clamp.
116	Solenoid coil insulation.
128	Washer for lead wire connection.
129	Rivet for top carbon clamp.
131	Screw for lead wire connection.
136	Base for copper electrode holder clamp.
137	Screw for solenoid—top lead wire.
138	Screw for top bracket.
144	Clamp complete for copper electrode holder.
145	Screw for carbon guide bars.
148	Fibre washer for push rod spring.
186	Top bracket only.
203	Wire for solenoid.
214	Lamp complete (includes No. 323 and No. 347).
220.	Carbon.
221	Holder complete with copper electrode.
223	Thumb screw.
225	Base for top carbon clamp.
226	Clamp complete for top carbon.
229	Base, for lamp.
250	Lead wire to copper electrode clamp.
255	Screw for top carbon clamp brush.
278	Washer for hand clamp.
292	Upper half guide bar with holder.
299	Set screw for lamp frame.
303	Screw for adjusting copper electrode.
304	Holder frame for copper electrode.
306	Jam nut for lamp base set screw.
307	Jam nut for copper electrode holder set screw.
310	Copper electrode.
316	Pin for copper electrode holder clamp.
323	Hand clamp, complete.
340	Stud for hand clamp.
341	Hand wheel for hand clamp.
347	Sub base.
349	Screw for bottom clamp.
378	Washer for binding post.
380	Washer for lift lever pivot pin.
381	Washer for screws 137, 349, 711.
391	Nut for tension spring post.
393	Thumb nut for upper half of guide bar.
515	Brush complete with screw for top carbon clamp.
616	Lamp frame.
617	Nut for binding post.

Part Number	Name of Part
618	Bushing for binding post.
619	Binding post base (large hole).
620	Binding post base (small hole).
621	Plunger for solenoid (see No. 739).
622	Link for solenoid plunger.
623	Pin for solenoid plunger link.
624	Top insulation washer for solenoid.
625	Bottom insulation washer for solenoid.
626	Binding post,complete(small hole).
627	Binding post, complete(large hole).
683	Piston for dash pot (not furnished separate, see No. 738).
708	Screw which supports clutch foot.
711	Post for tension spring.
713	Upper half carbon guide bar.
716	Pin for solenoid plunger link.
717	Dash pot cylinder (not furnished separate, see No. 738).
718	Pin for dash pot.
722	Thumb nut for tension spring screw.
723	Insulation for top bracket.
724	Fibre washer for bracket screws.
725	Bushing for tension spring post.
728	Tension spring (see No. 732).
730	Insulation for copper electrode holder clamp.
731	Solenoid complete (less plunger).
732	Tension spring, complete.
734	Lower half guide bar with guide ring.
735	Clutch foot, complete.
738	Dash pot, complete.
739	Solenoid plunger with link.
741	Bushing for bracket screw.
742	Compression spring for clutch foot.
771	Lock nut for clutch foot spring adjusting screws.
772	Lift lever, complete.
778	Holder for upper half guide bar.
779	Pivot pin for lift lever.
781	Clutch rod, complete.
785	Clutch ring.
5173	Washer for binding post.

Parts List Covering Accessories for Model D Turbine Generator

Part Number	Name of Part
125	Ball bearing grease.
230	Clamp and stud, complete, for reflector support.
246	Case and reflector (style No. 3).
325	Post for reflector support.
326	Clamp for reflector support (see No. 230).
327	Stud for reflector support (see No. 230).
328	Set screw for reflector support.
330	No. 8 S. B. W. P. Wire.
331	No. 14 S. B. W. P. Wire.
333	Key socket.
334	Keyless socket.
336	Switch, complete.
499	Special wrench for turbine-generator.
529	Nut for reflector support.
694	Incandescent lamp.
746	Porcelain receptacle.
1054	Nut for support clamp screw.
1913	Reflector support, complete.
2103	Switch handle.
2104	Switch handle guard.
2105	Pivot screw nut for switch.
2106	Pivot screw for knife blade of switch.
2107	Spring washer for switch pivot screw.
2108	Switch base.
2109	End contact finger complete for switch.
2110	Center contact finger complete for switch.
2111	Contact screw for switch.
2112	Washer for switch contact screw.
2113	Knife blade for switch.
2131	Lock washer for switch contact finger.
2132	Screw for switch contact finger.
2207	Convex clear glass for case No. 264

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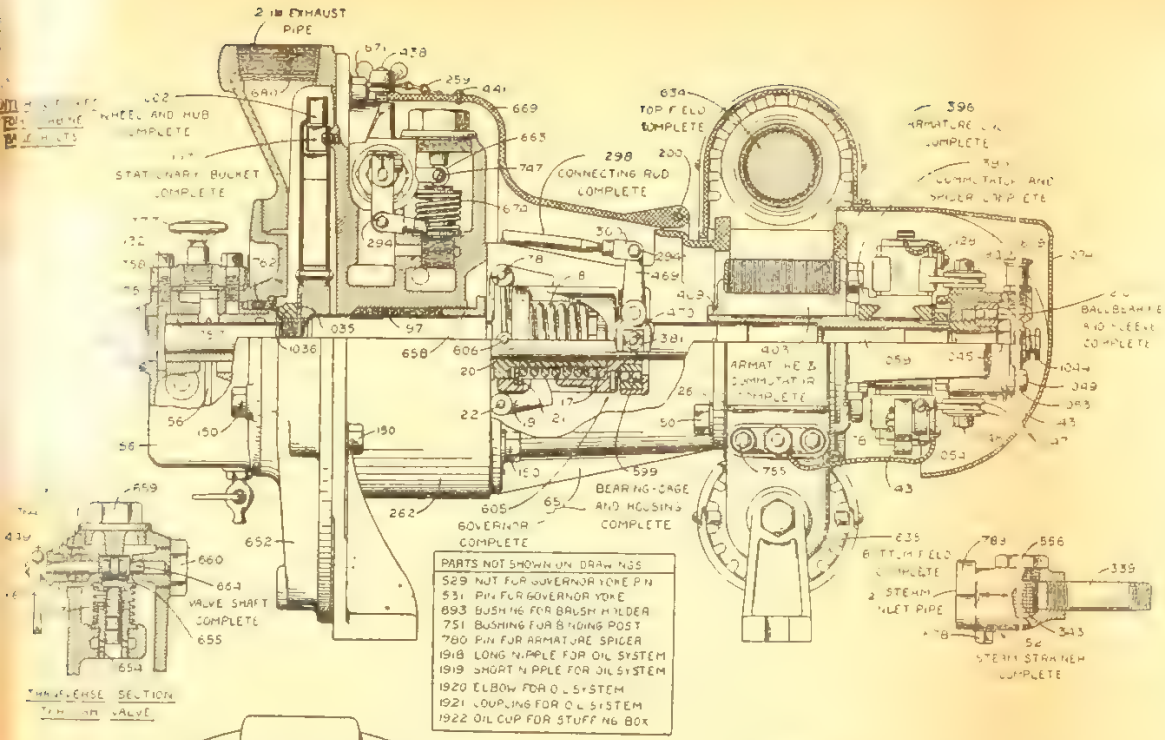
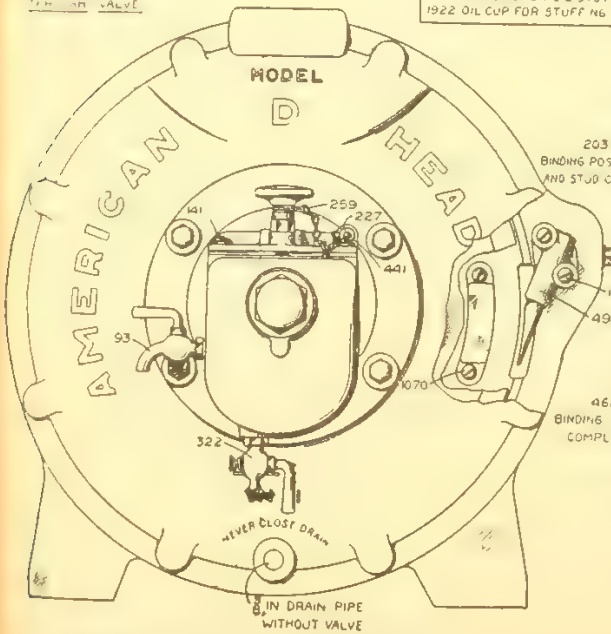
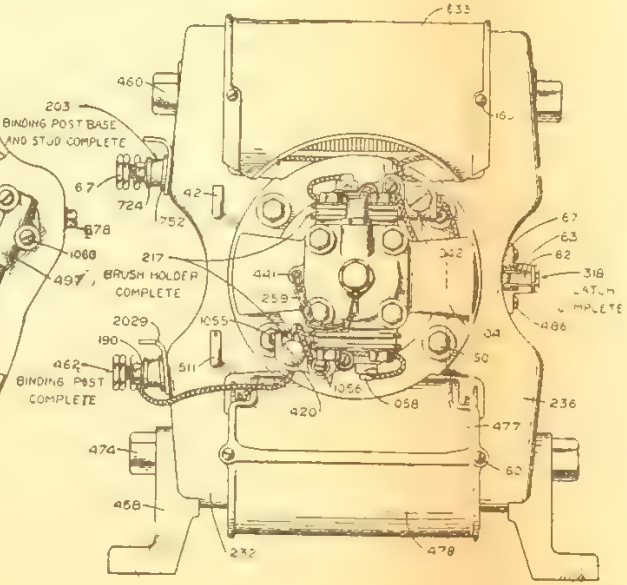


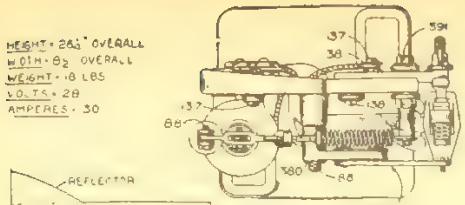
PARTS NOT SHOWN ON DRAWINGS
529 NUT FOR GOVERNOR YOKE PIN
531 PIN FOR GOVERNOR YOKE
893 BUSHING FOR BRUSH HOLDER
751 BUSHING FOR BINDING POST
780 PIN FOR ARMATURE SPIDER
1918 LONG NIPPLE FOR OIL SYSTEM
1919 SHORT NIPPLE FOR OIL SYSTEM
1920 ELBOW FOR OIL SYSTEM
1921 COUPLING FOR OIL SYSTEM
1922 OIL CUP FOR STUFFING BOX



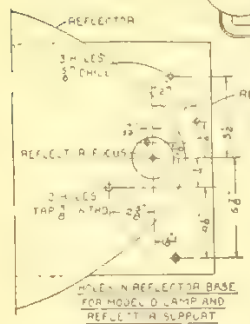


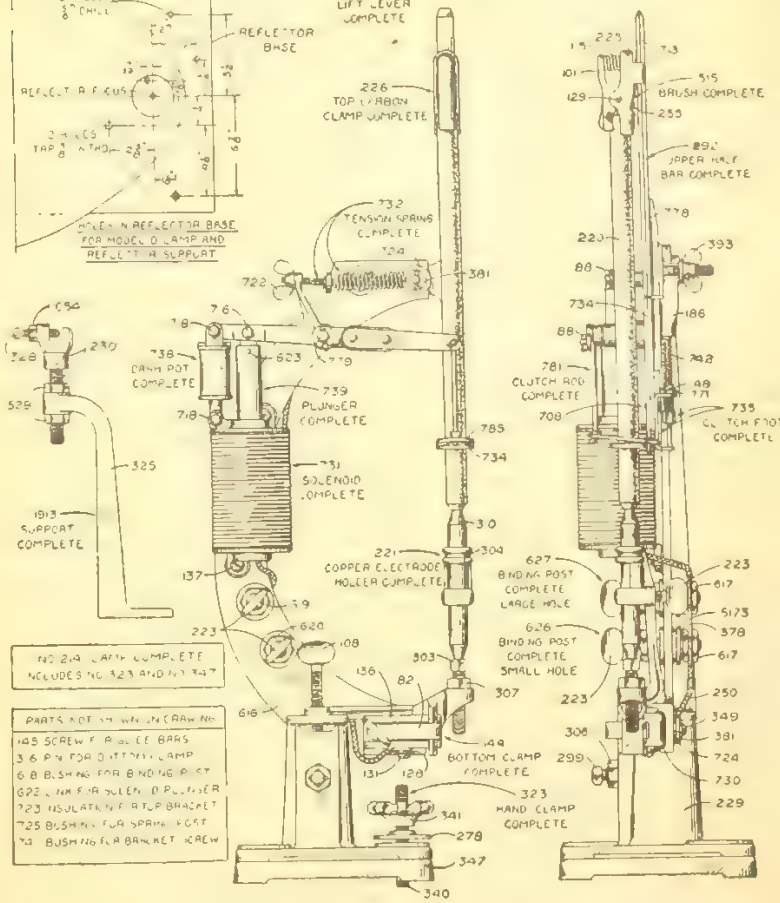
OVERALL LENGTH	27¼ IN	SPEED	2800 RPM
OVERALL WIDTH	27¼ IN	WEIGHT	240 LBS
OVERALL HEIGHT	17 IN	CAPACITY	1 KW

AMERICAN ELECTRIC HEADLIGHT
MODEL D TURBINE GENERATOR COMPLETE
-COMPOUND WOUND-STOCK NO 301



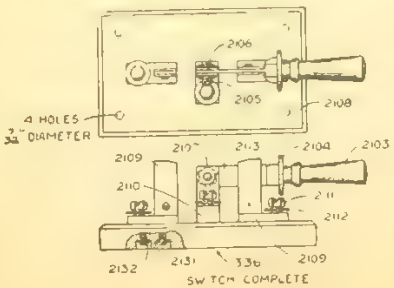
HEIGHT - 24½" OVERALL
WIDTH - 8½ OVERALL
WEIGHT - 18 LBS
VOLTS - 28
AMPERES - 30





NO 249 LAMP COMPLETE
INCLUDES NO 323 AND NO 347

PARTS NOT SHOWN ON DRAWING
105 SCREW FOR GUIDE BARS
336 PIN FOR DETENT LAMP
668 BUSHING FOR BINDING POST
622 LINK FOR HOLDEN PLUNGER
723 INSULATING STRIP BRACKET
725 BUSHING FOR SPRING POST
741 BUSHING FOR BRACKET SCREW



ACCESSORIES FOR MODEL D EQUIPMENT.

246 CASE AND REFLECTOR
330 NO 8 S B W P WIRE
33 NO 4 S B W P WIRE
333 KEY SOCKET
334 KEYLESS SOCKET
449 SPECIAL WRENCH
694 25 WATT INCANDESCENT LAMP
746 PORCELAIN LAMP RECEPTACLE
193 REFLECTOR SUPPORT COMPLETE

THE MOON ELECTRIC HEADLIGHT

The new electric headlight controls the light beam by means of an 18-inch inverted lens of the type used in light-house work. This projects a narrow beam of light down the track where it is wanted, and since the lens is placed in front of the arc, it is claimed that there is no direct glare of the arc in the eyes of the approaching engineer. Both arc and incan-

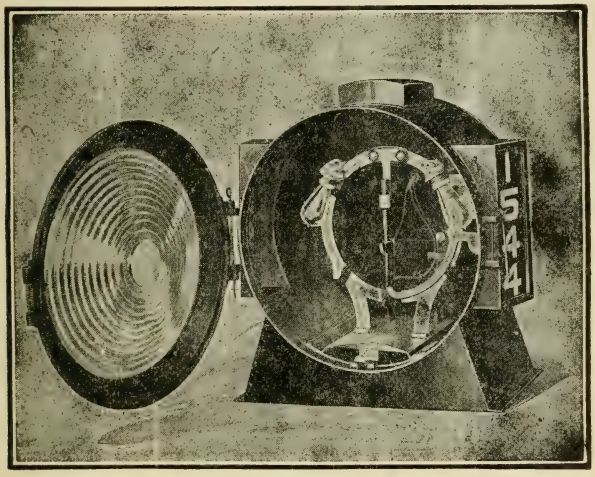


Fig. 1
Moon Headlight with Door Open

descent lamps are employed in this headlight, as shown in the accompanying illustrations. The arc is employed when on the road, but when standing on sidings, passing an approaching train on double track, running in yards or when standing in depots, the incandescent lamp may be operated instead of the arc, furnishing sufficient light and eliminating all the objections caused by the glare of the arc lamp. The arc, however, provides a high

power electric light for road service which is obtained by merely throwing a two-way switch in the cab, extinguishing the incandescents and cutting in the arc or *vice versa.*

In this headlight there is no parabolic reflector as is commonly used in this service, a concentrating lens alone being employed in front of the arc to direct the light rays in a narrow beam, as mentioned above. This, of course, eliminates the constant trouble and expense of polishing and renewing

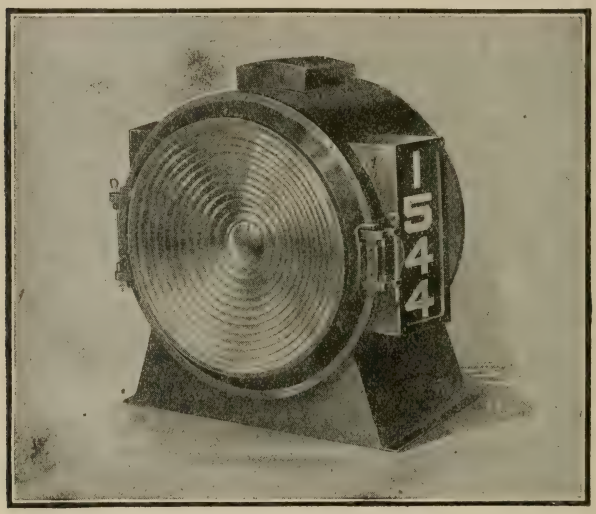


Fig. 2
Moon Headlight

reflectors, it being simply necessary to wipe off the glass lens.

With the parabolic reflector, the hottest part of the beam is in the center, decreasing uniformly toward the periphery, and this undoubtedly accounts for a large part of the glass breakage. With a lens, however, the light rays are picked up uniformly and projected therefrom and the heating effect is uniform and of low value.

In place of the customary carbons, the arc is produced by

electrodes, the positive of solid copper and the negative composed of magnetite in a steel tube. The arc of this headlight is then a magnetite flame arc and produces a brilliant white light of constant color. It will burn for 100 hours without renewing the electrodes. In fact, the upper, or positive electrode will burn for a year or more before it need be replaced.

As is shown in Fig. 3, the entire lamp mechanism is mounted on a sliding base and may be removed from the headlight by releasing an automatic lock. There are three contacts made at the back of the frame, as shown, and when the frame is

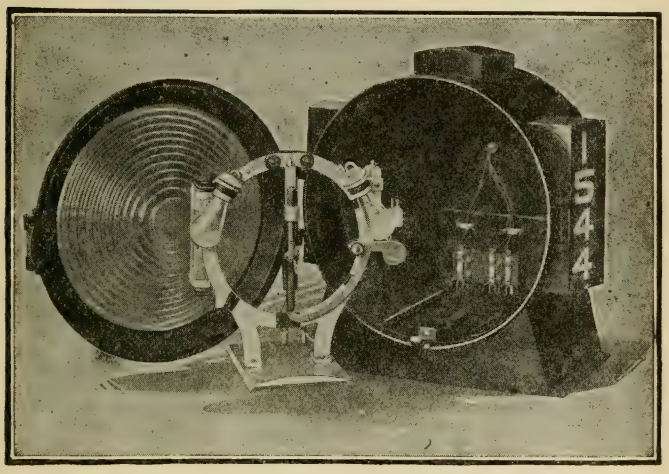


Fig. 3
Moon Headlight with Lamp Mechanism Removed

removed there are no wires disturbed. This frame, as shown in Fig. 3, carries the arc lamp, incandescent lamp, the resistance unit in series with the arc, and the operating mechanism. This latter is simply a balanced arm carrying the lower, or the negative, electrode and connects through a movable clutch to the operating plunger of the series lifting magnet. The arc once established, this arm is securely locked in place and no amount of vibration can disturb its position.

The automatic lock holds the lamp base and frame solidly in place and also provides that good contact be made at the back connections. The lamp frame is of channel section, forming a wire gutter in the back for running the wires around the frame to the lamps.

The projecting lens, as stated above, is mounted on the front door of the headlight; in addition to a spring latch, there is a pin lock on the door which prevents it from coming open. The case is heavy and both dust and water-proof.

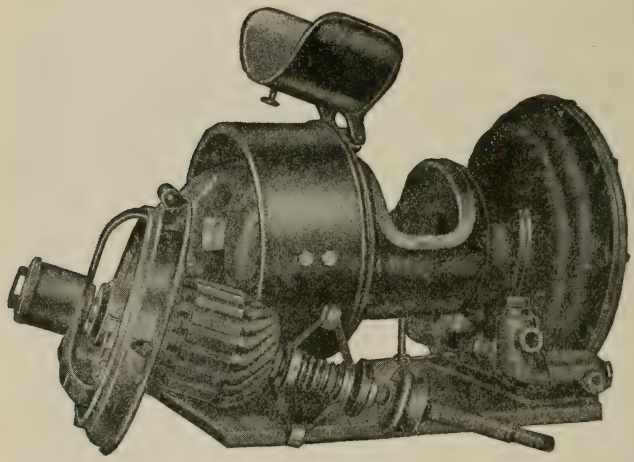


Fig. 4
Moon Headlight Generator with Armature Removed

The generator is of 1 K. W. capacity and is of standard generator construction throughout. The armature is form wound and there is a compound field winding provided which compensates for the variation in load occurring when headlight or marker lights are extinguished. The field coils are mounted on opposite sides of the frame and this eliminates the trouble sometimes experienced when oil soaks into the lower field coil and destroys its insulation. The commutator end may be opened for inspection and repaired by simply lifting

the end housing. This, when closed, completely seals the generator so that it is both dust-proof and water-tight.

The turbine wheel is of special construction and is rustless pressed steel with a bronze mounting. This combines strength with smoothness of surface, which is so essential in turbine construction where steam passes over metal at a very high velocity. It has been conclusively shown that the higher the polish which can be obtained on the surface of the buckets, the less resistance is offered to the steam passing through it.

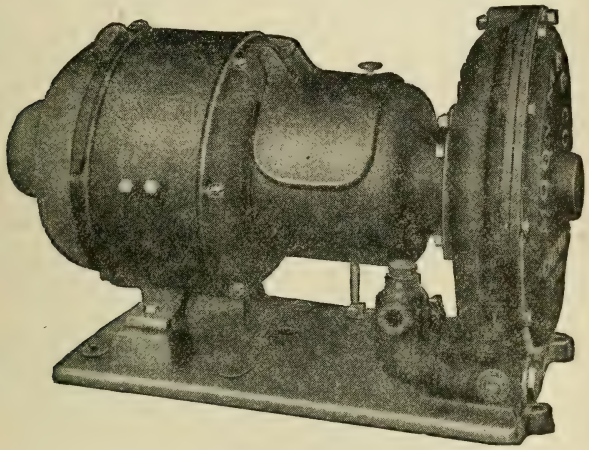


Fig. 5
Generator Set — Moon Electric Headlight

Steam is emitted from two nozzles $\frac{3}{16}$-inch in diameter located on diametrically opposite sides of the wheel, forming a balance of torque which eliminates all stress on the bearing. There are no moving parts in the steam with the exception of the turbine wheel.

The turbine head is provided with a specially constructed opening where the shaft enters it, which eliminates the use of packing entirely.

In case it becomes necessary to remove the turbine wheel, after removing the end housing of the turbine, the lock nut

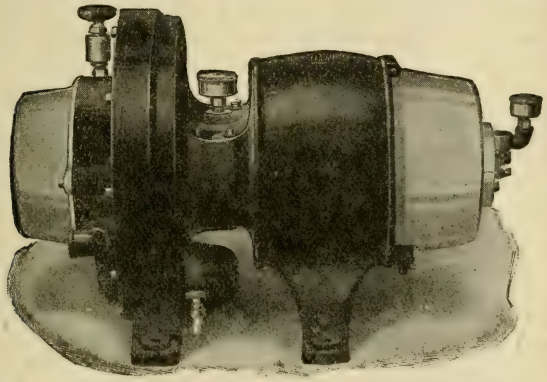
on the end of the shaft first loosens the turbine wheel, and upon being unscrewed farther, acts as a puller nut and pulls the turbine wheel from the shaft. Similarly, if it becomes necessary to remove the armature, the retaining nut first releases the armature, then acts as a jack which forces the armature off the shaft.

The governor which operates the control valve is of special design, unique, and exceedingly sensitive in its action. The connections from the governor to the balance valve are of bronze and case hardened steel as shown in Fig. 4. The machine is provided with ball bearings throughout, there being no rubbing contacts with the exception of the brushes on the commutator. The general construction is of circular form, enabling all finished parts to be turned to a true surface, thus insuring more perfect fitting and better standardization of parts. The casing is both water and dust-proof and ample provision has been made for easy inspection of parts. On account of the exactness and standardization in manufacturing, which are rigorously maintained, all parts of this equipment are made so as to be readily replaced with new parts to fit accurately.

The equipment operates on from 30 to 40 lbs. of boiler pressure, consuming about 170 lbs. of steam per hour, to maintain the headlight and cab lights. By means of the compound windings of the generator and the accuracy with which the turbine is governed the cutting out of the headlight has no appreciable effect on the cab lights, the voltage remaining practically constant. The equipment operates at the standard voltage of 110, and with a capacity of 8 amperes or 900 watts, although the arc headlight and cab lights consume only 600 watts.

SCHROEDER ELECTRIC HEADLIGHT

TURBO-GENERATOR (See Fig. 1). The Turbo-Generator is designed to operate at all practical steam pressures developing 30 volts at 2400 R. P. M. with load (arc lamp in circuit) and about the same voltage at 2550 R. P. M. with incandescent lamps only, but owing to variation in magnetism of castings, the speed may be slightly above or below this, therefore be governed by arc load speed indicated on name plate. To determine the speed, remove plug No. 327 and insert indicator.



Schroeder Electric Headlight Generator and Turbine

GENERATOR. Generator is compound wound and incandescent lamp in headlight case can be used independent of the arc. Switch in cab is provided for cutting out arc and substituting the incandescent in the headlight.

OILING. Special attention is called to oiling this equipment as no machinery will work properly without lubrication. Main and end bearings should be lubricated with Polarine grease, or its equal and cups must be given two or three turns once

a week. Lubricator 318 on turbine must be filled with cylinder oil each trip.

SPEED ADJUSTMENT. Remove cover A305, loosen lock nut 363 and turn adjusting nut 362 to the right or left by means of a special wrench supplied with each outfit. Turning nut 362 to the left reduces the speed; to the right increases it. Moving same in either direction, a half turn will make a marked difference in the speed. Further variation can be accomplished by altering travel of valve piston (not to exceed $\frac{3}{16}$") which is done by adjusting lever stud 370. Under ordinary conditions, however, no other speed adjustment is desired or necessary than by means of adjusting nut 362.

Care should be taken in changing governor after it has once been adjusted, as variation in speed may be caused by reasons such as foreign matter in strainer, valve stem not working freely, lamp not being adjusted properly, or by short circuit, etc.

STRAINER. The strainer is provided for the purpose of protecting machine from foreign matter, such as boiler, pipe scale, etc. Plugs are provided and can be readily removed for cleaning. Should lamp burn dim for reason of machine running slow, examine this strainer.

PIPING. Equipment should be piped with $\frac{3}{4}$-inch pipe; carefully blow out pipe before connecting to turbine.

When mounting this equipment, make platform or brackets perfectly level so that all standards rest firmly on same.

Generator requires only ordinary care. The mica between commutator bars should be cut down to below the surface occasionally.

Brushes are to be renewed after wearing down to about one inch in length. Use only enough tension on springs to prevent brushes sparking.

ARMATURE. In order to remove armature take off front bearing housing cap 376 then take out shaft screw 343, uncouple wire from brush holders, and front bearing housing 375 can be removed after taking out screws 377. Unscrew lock nut 336 (left hand thread) and armature can be drawn from shaft.

TURBINE WHEEL. This can be removed from shaft by taking off cover A305, tap bolts 377, and nuts 349 which will allow turbine head A301 to be removed; next unscrew governor from shaft by taking out governor lock screws 365 and screws 315 holding stationary buckets. Wheel and buckets are made of pressed steel well tinned after assembling to prevent rusting.

STATIONARY BUCKETS. In replacing stationary buckets A314 the side showing rivet heads should be towards governor end. It will also be noticed that the stationary buckets stand in the opposite direction to those on the wheel.

SHAFT. If it is necessary to remove shaft, take off wheel and front bearing housing as instructed, unscrew bearing lock nut 344 and withdraw shaft. In replacing same care must be taken to see that deflector dowl pin enters key-way in shaft.

When machine has been completely assembled draw lock nut 344 tight as possible.

CENTER BEARING. To get out center bearing; remove wheel, shaft and armature as instructed, take out screws 304 and remove cap 303. This can be done without taking out the bearing housing A302.

END BEARING. This can be taken out by removing cap 376, shaft screw 343 and bushing 333.

GREASE. Main and end bearings should be lubricated with Polarine grease (or its equal), giving the grease cups two or three turns about once a week.

END THRUST. Alteration in end thrust can be had in either direction by adjusting collar 335 and screws 328.

GOVERNOR. The ball 359 is oiled through oil channels from lubricator 318. Lubricator should be filled before each trip.

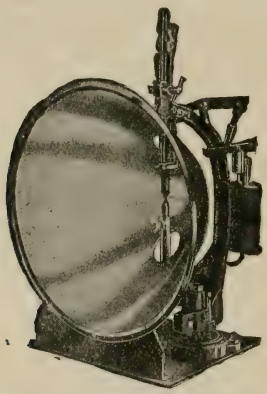
VALVE. Valve is made of a special metal of the balanced piston type and ought to be renewed after being in use about a year. Care should be taken in packing valve, so as not to draw gland 354 too tight as piston must be allowed to move freely.

HEAD LAMP (See Fig. 2). Under normal conditions, lamp will give steady and brilliant light, without flickering, when locomotive is running at full speed or standing still. Flickering may be caused by the following defects:

Piston is too loose in dash pot. Dash pot and piston should be replaced.

Too much lost motion in the connecting links. Worn parts must be renewed.

The wires in connecting posts may be loose: examine these and all other connections carefully.



Schroeder Electric Headlight

Flexible copper contact 251 has not proper bearing against guide 204: bend spring slightly. Caution: excessive contact will not allow lamp to feed.

Speed of turbine is not high enough, consequently the generator does not develop proper voltage. Increase speed.

Speed of turbine is too high. Lamp will flicker, flame, and turn green. Reduce speed.

Before changing speed, it is advisable to examine lamp as same may burn green on account of wires having become crossed in binding posts. Lamp gives the strongest and steadiest light at about 28 or 29 volts and from 30 to 32 amperes.

If carbon burns away too rapidly it indicates that tripping spring 209 is too tight and same should be loosened by means of clutch adjusting screw 245 until the lamp does not consume more than about 30 amperes.

Should the arc dim occasionally when the locomotive is running, and the cab lights dim at the same time, it shows the tripping spring 209 is too weak and must be tightened or renewed. Again, if the arc burns good on the road but goes out when locomotive stops, this spring is too loose or dash pot is too tight, or carbon is not feeding properly.

After a carbon has been put in lamp, it should be seen that it raises and falls freely, and see that it is in line with electrode.

The wire from lower binding post, see Fig. 3, which has a large hole should be connected in negative terminal on dynamo, otherwise electrode will fuse.

When properly adjusted and headlight arc is burning, plunger 224 should be about ½ inch from bottom of solenoid. On the contrary, if plunger is allowed to travel to the bottom of solenoid the lamp will draw too much current. If too high arc will have a tendency to flicker.

Tension on spring 209 should be just sufficient to trip carbon when current is cut out. If unnecessary tension is placed on same, lamp will draw too much current causing carbon to burn away quickly and cause generator to do heavy duty.

Fusing Copper Electrode. The fusing of copper electrode may be caused either by too high speed or by wires reversed in lamp. In the latter case change them back.

With this equipment it is not necessary to file copper electrode each trip; copper should be retapered about once a week.

Headlight failures can often be avoided by a little care being exercised by engine crew, if they will see that all screws and bolts are tight before starting out on trip and generator properly oiled.

Focus Adjustment. In order to get the best and most far-reaching beam of light the arc must be located in the

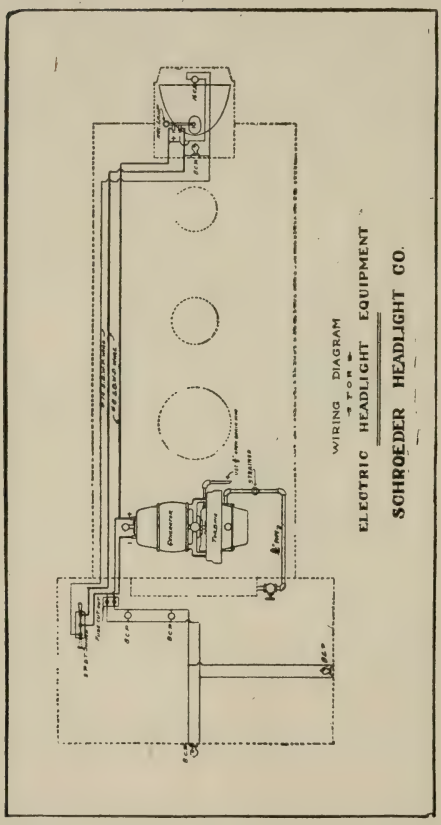
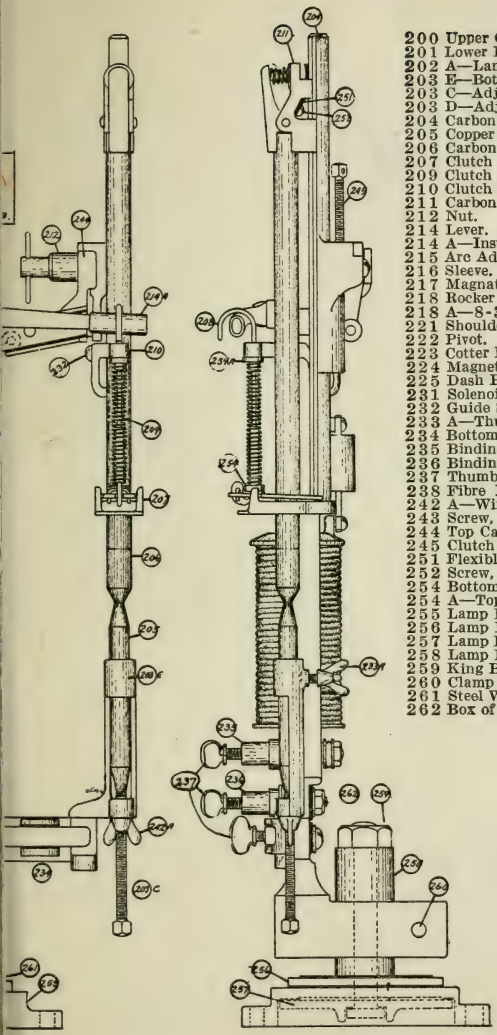

WIRING DIAGRAM
FOR
ELECTRIC HEADLIGHT EQUIPMENT
SCHROEDER HEADLIGHT CO.

Fig. 3.



200 Upper Carbon Holder, complete.
201 Lower Electrode Holder, complete.
202 A—Lamp Frame.
203 E—Bottom Electrode Holder.
203 C—Adjusting Screw.
203 D—Adjusting Screw.
204 Carbon Holder Guide.
205 Copper Electrode.
206 Carbon.
207 Clutch and Rod.
209 Clutch Spring.
210 Clutch Guide.
211 Carbon Holder Clamp.
212 Nut.
214 Lever.
214 A—Insulation.
215 Arc Adjusting Screw.
216 Sleeve.
217 Magnate Link.
218 Rocker Arm.
218 A—8-32 Screw.
221 Shoulder Screw, 14-20.
222 Pivot.
223 Cotter Pin.
224 Magnet Plunger and Link.
225 Dash Pot, complete.
231 Solenoid.
232 Guide Screw.
233 A—Thumb Screw.
234 Bottom Electrode Holder Support, comp.
235 Binding Post, Small Hole.
236 Binding Post, Large Hole.
237 Thumb Screw.
238 Fibre Insulation.
242 A—Wing Nut.
243 Screw, 14-20.
244 Top Carbon Holder Support.
245 Clutch Adjusting Screw.
251 Flexible Copper Contact.
252 Screw, 6-32.
254 Bottom Steel Collar.
254 A—Top Steel Collar.
255 Lamp Base.
256 Lamp Base Clamp Top.
257 Lamp Base Clamp Bottom.
258 Lamp Base Column.
259 King Bolt and Nut.
260 Clamp Screw.
261 Steel Washer.
262 Box of Assorted Screws.

SCHROEDER HEAD LAMP

Fig. 2

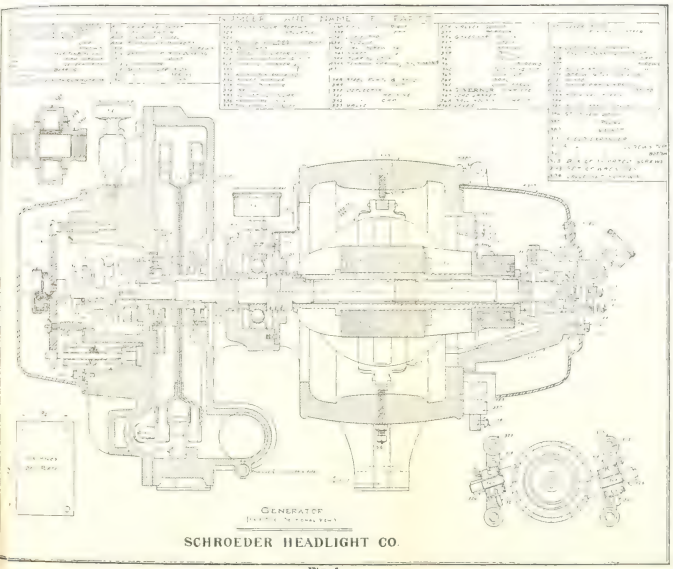
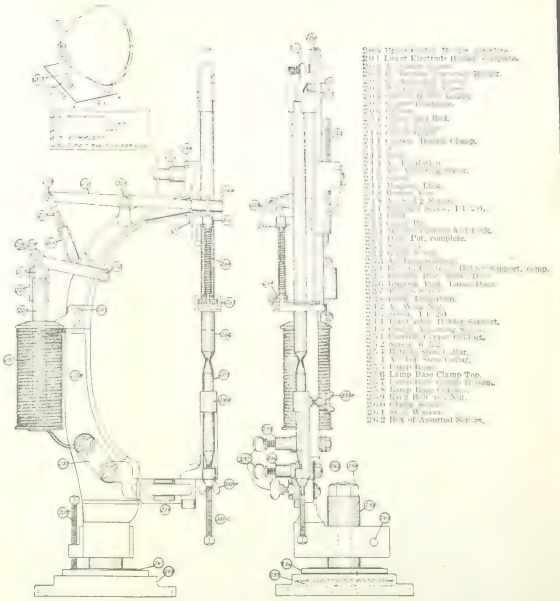


Fig. 1



SCHROEDER HEAD LAMP

Fig. 2

focus of reflector. The following points should be observed when focusing the lamp:

If the lamp throws light in the form of large cone and shows dark spot in center, arc is too close to back of reflector. The same trouble may occur when lamp is too far from back of reflector, but in this case it will be noticed the rays cross in the air.

These adjustments are accomplished by loosening clamp screw 260 and moving lamp in either direction.

If the light does not throw straight on the track, but deviates to the right or left, adjustment can be had by loosening nut 259 and shifting lamp on base to desired direction.

If light is properly focused in reflector, and beam of light does not strike center of track, it indicates that the case is not square on engine. Bolts should be removed and case shifted.

Top of copper electrode should be about 1½ inches above top of holder.

Should any other adjustment be necessary for raising or lowering the light adjust frame on stand.

Don't try to focus the lamp by raising or lowering the back of reflector. Front of reflector should be kept parallel with the front glass.

In moving lamp to obtain proper focus take care that the lamp does not touch the reflector, as a ground or short circuit will result, which may burn out the generator.

Incandescent lamps used in cabs must be same voltage as generator: 30 volts.

BUDA-ROSS ELECTRIC HEADLIGHT

The Buda-Ross equipment complete consists of Turbo Generating Set, the Arc Lamp, 90 feet No. 8 wire, material for 4 incandescent lights in the cab, 6 carbons, 1 single pole double throw switch.

ENGINE

To Set Governor. To set the governor valve see that carbon ring holder No. 233 is set about flush with the end of the center piece No. 236, and have set screw No. 726 in slot in side of carbon ring holder. Place bell crank No. 237 on support No. 241 in position and see that it works freely. Place wheel No. 202 on shaft No. 324 and tighten same with nut No. 323, with washer No. 322 under nut. Place valve stem No. 238 in inner sleeve No. 239 and lock nut No. 243 tightened down, having spring No. 245 between lock nut No. 274 and valve stem fork No. 273 and see that it works very freely. The lower edge of hole in valve steam should be in line with lower side of hole in inner sleeve No. 239, thereby giving full opening of the valve. Place inner sleeve with valve in bushing No. 240, being careful to have fork end of valve stem pass over end of bell crank No. 237 and screw inner sleeve down until opening through valve stem No. 238 and inner sleeve No. 239 is reduced to about $\frac{3}{16}$ of an inch. Then tighten lock nut No. 243 and apply cap nut No. 242. If openings in valve and inner sleeve do not come about central with the steam port in main casting, wheel should be removed and carbon ring holder No. 233 adjusted, (inwardly) to bring valve lower, and (outwardly) to bring valve higher. Then replace wheel and see if opening in valve comes central with steam port in main casting.

Steam Nozzles. In applying high pressure nozzle No. 246 and auxiliary nozzle No. 282, have them as close to the buckets as possible and clear. After the wheel is applied it

should be revolved slowly to see that none of the buckets strike. False seat No. 247 is used under high pressure nozzle, but no false seat is used under auxiliary nozzle.

Renewable Buckets. The Buda-Ross buckets No. R-202B are attached to a removable annular ring No. R-202A, and held in place on the turbine wheel No. R-202 by screws No. 720. In renewing buckets, turn screws out about half way when the ring No. R-202A can be driven out of the wheel by driving screws back. The screws can then be removed entirely and another ring of buckets substituted.

To Remove Wheel. To remove wheel, remove lock nut No. 323 and washer No. 322, then strike wheel near hub a sharp blow with a hammer, or hold dynamo end of shaft and strike engine end of shaft a sharp blow with soft hammer which will immediately loosen the wheel on the shaft.

Speed of Equipment. The speed of this equipment should be kept as near 2,800 revolutions per minute as possible, but if the bottom electrode fuses or the light burns green it should be reduced until this trouble stops. This burning green is controlled considerably by adjustment of the equipment, thus all equipments cannot be run at the same speed.

To Regulate Speed. To regulate speed, have opening of valve about $\frac{3}{16}$ of an inch and tighten or loosen governor adjusting nuts No. R-716 until the speed is as near 2,800 revolutions per minute as possible. After this it will not be necessary to adjust these nuts, as speed can be regulated by adjustment of inner sleeve No. 239. To reduce speed, screw this inner sleeve No. 239 down one-quarter turn at a time. To increase speed, screw up one-quarter turn, but care must be used to see that it is not so high that the speed will not be controlled when load is removed. Although the steam cannot be cut off at any position of this sleeve, yet the square on top of it should be straight with shaft and not cornerwise as a better opening is then had.

Ball Bearing. There is a special annular ball bearing on the dynamo end of the shaft in the box yoke connecting the engine to the dynamo. The ball bearing is enclosed in the ball bearing housing No. 701 and retained by retaining ring

No. 702 which also serves as a support in box yoke No. 700. This ball bearing housing is threaded and is adjusted in the end of box yoke No. 700 for the purpose of bringing the buckets No. 202-B in perfect alignment with the steam nozzle No. 246. It is then locked by lock screw No. 706. This bearing is held on the shaft by pin No. 749, which engages in slot in ball bearing No. 703 on one side, and a sleeve No. 704 on the other side. If these two engagements are properly made, armature pin No. 748 can then be inserted at the end of the sleeve No. 704. If they are not properly engaged this pin cannot be inserted in hole in the shaft. On the inner end of sleeve No. 704 is a collar which, running inside of ball bearing housing No. 701, takes all the end thrust towards the dynamo thereby relieving all end thrust from the bearing.

To assemble this bearing in the housing, insert sleeves No. 704 in the housing No. 701 with flange end inside, place ball bearing in housing and see that lugs on end of sleeve are in slots of ball bearing then screw retaining ring No. 702 into housing No. 701 down to its seat and secure it by lock screw. The assembled bearing is then ready to screw into the end of box yoke No. 700. A piece of 2-inch iron pipe with two slots in one end to engage lugs on end of No. 701 makes a good wrench for this purpose.

The ball bearing housing No. 701 should be adjusted so that buckets No. 202-B on the wheel No. 202 will come directly in line with the inlet steam nozzle No. 246 and is then held in place by set screw No. 706 which should enter one of the grooves in No. 702 on the end of the housing instead of on the rib, and lock nut No. 705 should then be tightened down.

To change cap bearing No. 218, remove oil box No. 204 from the cap No. 203 by removing four cap screws No. 746; remove two screws in the end of oil box which hold bearing tight; remove No. 211 and No. 210 and the bearing No. 218 can then be driven out of the oil box.

To apply new bearing, have oil ring No. 205 in proper place on bearing and insert screw end of bearing in oil box, forcing it up to place in oil box and applying both screws which hold it tight against the shoulder and from turning.

Bolt oil box to cap No. 203, apply end thrust plug No. 210, with round hole towards end of shaft and tighten up end thrust cap nut No. 211 allowing about 1/64-inch play *after nut is tightened up.* Be sure to try the end thrust after nut is tightened as plug No. 210 may be moved by tightening the nut.

Oil. *Valve* or *cylinder oil* should be used in this bearing which is introduced through plug No. 219. This bearing should be oiled each trip.

Shaft. The shaft can be removed from the bearing in box yoke by only removing armature pin No. 748, the pin No. 749 being short enough to pass through the stuffing box in the engine.

Auxiliary Valve. Auxiliary valve No. 277 should be placed in bushing in main casting No. 276 with lug downward, then screw cap nut No. 275 down to its seat. Insert spring No. 281 in lower opening in main casting and screw adjusting stem No. 279 into lower end of bushing, adjusting tension so that valve will operate at about 150 steam pressure. Then tighten up lock nut No. 280. All adjustments of this valve are made from the outside.

Lead Wires. Lead wires from dynamo to lamp should be No. 8 B. & S. gauge slow burning weatherproof wire.

Incandescent Wires. Incandescent wires in cab and classification lamps should be No. 14 B. & S. gauge slow burning weatherproof wire.

Wiring. All wiring should be run in conduit or protected in some efficient manner so that insulation will not be disturbed and cause trouble. Wiring should be done conforming as closely as possible with wire diagram shown in tip.

Field Coils are all compound wound permitting the burning of either arc lamp or cab lights independently, or both of them together. All Buda-Ross field coils are alike and will work equally well in the right or left side of the dynamo. They have three (3) terminals which are painted red, white and black.

To apply field coils, place the coil over the round portion

of the pole piece No. 209 with red terminal towards the back of the dynamo, and place the pole piece on the dowel pins No. 750 in the side of the dynamo and fasten with cap screw No. 709 very tightly, being sure to have the surface on the end of pole pieces and inside of dynamo clean to make a close contact. Connect both white and black terminals of left-hand field to insulating binding post No. 228 on left side of brush holder between insulating washer and binding post nut on back side of brush holder No. 341. The current therefore enters the binding post but must be insulated from the brush holder. Connect black terminal on right-hand field to screw No. 712 on top brush holder. Connect white terminal to binding post No. 229 on right side of lower brush holder. Connect the two *large* red terminals of the right and left-hand fields together at the back of the dynamo with the wire coupler and tape joint thoroughly. Connect both *small* red terminals of the right and left-hand fields together at the back of dynamo and connect with small wire coupler and tape joint thoroughly.

To remove field coils No. 853, disconnect field wires from top and bottom brush holders, remove cap screws No. 747, take off front of dynamo, also cap screws No. 709 from end of pole pieces No. 209 on outside of dynamo then the field coils and pole pieces can be withdrawn.

To change field coils, disconnect all wires from the brush holders, remove the front part of the dynamo from the rear part, then remove cap screws No. 709, and the pole pieces No. 209 can be taken out and the field coils No. 853 slipped over the end and replaced very readily, and at the same time it will not be necessary to remove the brush holders.

Brush Holders. When applying brush holders they should be insulated from the dynamo by fiber washer No. 297, fiber bushing No. 315 around the screw, and fiber washer No. 295 between head of screw and brush holder. The positive binding post with large hole should be insulated from the brush holder in the same manner. In applying new brush holders, fasten them securely to the dynamo, insert the brushes and if the brush does not come in perfect alignment with the commutator, bend the brush holder in or out and bring them in line.

SPEED OF ARMATURE. All Buda-Ross armatures are interchangeable. The speed of the armature should be as near 2,800 revolutions per minute as possible, unless the copper electrode burns off when it should be reduced until the copper electrode does not burn.

REMOVING ARMATURE. To remove armature, disconnect the lead wires and turn brush holders up or down out of the way, remove the small lock screw No. 724 in washer No. 216 on end of shaft, and cap screw No. 716 with washer No. 216 and armature can then be pulled off of shaft. Or, remove four (4) cap screws No. 747 on back of dynamo, remove front of dynamo, remove lock screw in washer No. 216 on end of shaft and cap screw No. 716 with washer No. 216. Sometimes an armature will stick on the shaft so that it cannot be readily removed. In this case it is very convenient to remove the front of the dynamo when access can be had to the rear of the armature and thereby very readily removed. Brush holders need not be disturbed to do this.

CARE OF COMMUTATOR. The commutator should be kept perfectly clean with a damp piece of waste, rubbing endwise, so as to keep the creases between the copper strips clean where mica is filed out, then wipe clean with dry waste. No lubricant nor commutator paste should be used as it very soon collects dust on the commutator. The mica insulation between the strips in the commutator should always be kept a trifle below the surface of the copper, although care should be taken to only have this slightly below the surface, as otherwise it will form a receptacle for dirt which, being a conductor of electricity, will cause a short circuit in the commutator. A small three-cornered file has been found best for the purpose of cutting this mica down. If the commutator becomes rough or out of round, it should be trued up in a lathe. The tool used must be very sharp and light cuts must be taken, then polish it with fine sandpaper. It must be carefully examined to see that no two sections touch as the copper is liable to lag or burr from one section to the other, and before putting it back it would be better to cut or file the mica (between each section) a little below the surface for it does not wear away as fast as the copper and if the mica is not cut away it may

lead to sparking. After doing this be sure no ragged edges of copper stick up for this will cut away the brushes rapidly.

To Fit Brushes. To fit brushes to the commutator when they are new, take a piece of No. 0 sand-paper (not emery paper) about the width of the commutator, place this under the brush and over the commutator with the sand-paper next to the brush, and draw this forward and backward between the commutator and brush until there is a perfect contact made on the face of the brush. After this, care should be taken not to disturb this contact by cleaning the face of the brush with a knife and sand-paper or file as it only helps to wear out the brushes, and also destroys the perfect fit on the commutator.

Brush Tension. The tension of brush holder spring No. 342 should be adjusted with adjuster No. 343 by loosening screw No. 743, only strong enough to prevent sparking from some sudden jars of the locomotive, and when once adjusted will not need additional attention. Care should be used to see that the contact of the brush is perfect on the commutator before adjusting the spring No. 342, for with a poor contact no adjustment of the spring will stop the sparking, and if the tension is too strong there will be undue friction on the commutator, and consequently heat. "Pig-tails" on brushes should be connected under screw No. 719 on brush holder.

How the Lamp Works. The current should enter lamp at positive binding post, with large hole, No. 228. It then passes through connecting wire to top bracket No. 257; also through top carbon holder No. 303 down through carbon and lower electrode holder bracket No. 300, through lower bracket No. 252 to solenoid wire, then through solenoid No. 865, and thus to negative binding post, with small hole No. 229. The magnet core No. 264 is suspended at the end of magnet lever No. 259. The current passing through wire on solenoid No. 865 creates a downward magnetic pull on the iron core No. 264, thereby actuating lever No. 259, fulcrumed at screw No. 769. The other end of lever No. 259 being located under clutch weight No. 287 raises clutch weight No. 287 and clutch weight rod No. 306 actuating clutch lever No. 305 which

allows clutch No. 304 to grip carbon. The downward pull of this solenoid armature therefore pulls up on the clutches and separates the carbon from the electrode, thereby forming an arc between the carbon and the electrode.

INSULATION. The lamp should be insulated between bottom bracket No. 252 and frame No. 251, between top bracket No. 257 and frame No. 251 and between end of lever No. 259 and dash pot No. 861 and magnet link No. 263. These points should be examined occasionally to see that carbon dust has not accumulate on them, thereby causing a vehicle for current to pass through.

PERFECT CONTACT. The carbon and copper electrode must have a perfect contact before the light will burn, otherwise no circuit can be established. A deposit is sometimes found on the point of copper electrode which prevents this contact and therefore this deposit should be removed when a new carbon is applied in lamp.

COPPER ELECTRODE. The copper electrode should extend about 1 inch above the upper end of copper electrode holder No. 300. This electrode can quickly be raised by loosening thumb screw No. 781 and raising electrode clamp No. 301 at a higher point on the holder taking care to see that the thumb screw No. 781 is again tightened securely in slot. If copper electrode burns off, equipment is running too fast, or the wires are crossed, and it should then be determined where trouble exists. If found to be running too fast, governor adjusting nuts No. 716 should be turned to the left, thereby reducing tension on springs taking care to adjust nuts on both sides of the wheel alike. One-half turn of these nuts will change the speed about 50 revolutions per minute.

CARBONS. Use $\frac{5}{8}$ x 12-inch copper coated forced carbons which should be smooth and straight and of uniform size. One carbon should burn about eight hours. However, high speed of the dynamo or a draught of air in the headlight case will cause the carbon to be consumed faster.

It should be noted when putting in a carbon that the end of the carbon rests central on the point of copper electrode. After putting in a carbon, push down on lever No. 259 and

see that the carbon lifts and falls freely in the clutch No. 304 and rests centrally on the point of copper electrode.

ELECTRODES. If the top and bottom electrodes do not come central, top carbon holder No. 303 can be bent slightly to bring them in line. Do not bend lower holder No. 300.

ADJUSTMENT. In applying top carbon, the top of the carbon should be inserted in the top of carbon tube No. 302, no other guide being necessary. Be careful to see that the carbon will fall through the clutches easily by gravity, otherwise the lamp will not feed properly. The flat tension spring No. 308 on the top of the lamp is for the purpose of counterbalancing the weight of lever No. 259 and iron core No. 264 in solenoid so that clutches will release the carbon.

CARBON FEED. If, by pushing down on outer end of lever No. 259, the arc cannot be broken when lamp is burning, the movable clutch No. 304 is probably worn so that it does not grip the carbon soon enough and a new clutch should be applied, or the clutch rod No. 306 shortened. If, however, this clutch rod is adjusted too short, the carbon will stick in the clutches causing light to go out.

IF LIGHT FAILS TO START. If light fails to burn when turning on steam proceed as follows: Disconnect one of the incandescent wires from the binding post No. 711. See that the point and sides of the copper electrode are clean and that the carbon rests on the electrode. See that lever No. 259 will lift carbon and that carbon falls through clutch No. 304 freely.

TESTING FOR SHORTS. Place a piece of carbon across the binding posts No. 228 and No. 229 of the lamp for a few seconds and if, when removing the carbon, there is a flash it indicates that there is no trouble between this point and the dynamo and the trouble must be in the lamp some place ahead of this point. Place a piece of carbon across the binding posts No. 228 and No. 229 of the dynamo, and if there is a flash dynamo is all right. If there is no flash at the lamp and a flash at the dynamo, the trouble is in lead wires. If there is no flash at the dynamo the trouble is probably in incandescent wires, fields or armature and therefore test for the trouble. This may be caused by a dirty commutator, pre-

venting the brushes from having a good contact with the copper segments of the commutator.

TENSION SPRING. The tension on spring No. 308 should be adjusted as loose as possible and at the same time have the clutch release the carbon. The greatest efficiency will then be secured from lamp when locomotive is running. If the tension spring No. 308 is too loose, the light will go out when the locomotive is standing. If the tension spring is too tight the magnet may not separate the carbon sufficiently to establish the proper arc and a heavy current will be passed through windings. This is determined by too great a heat in the solenoid. If the heat becomes too high it will destroy the insulation on the windings and result in a very poor light.

ADJUSTMENT OF LAMP. If light goes out when the locomotive is at rest, tighten tension spring adjusting screw No. 758 about one-half turn at a time until light burns properly.

LIGHT DIES DOWN. If the lamp burns while locomotive is standing still and dies down while running, and the faster locomotive runs the more light dies down, it is probably due to the fact that either the clutches are worn or carbon holder spring No. 307 is adjusted a little too loose.

LIGHT BURNS GREEN. If the light burns green the dynamo is either running too fast or the wires are connected wrong, when the speed should either be reduced by adjusting the governor or reversing the wires in the binding posts. If the wires are connected wrong the light will burn green all the time. If the speed is too high it may only burn green periodically. If the speed is found too great it can be stopped immediately by throttling the steam in the cab. Or remove cap No. 242, loosen lock nut No. 243 and screw down inner sleeve No. 239 about one-half turn, which will reduce the speed, again tightening up lock nut No. 243 and replacing cap nut No. 242.

TO FOCUS LAMP

1. Adjust back of reflector so front edge will be parallel with front edge of case.
2. Adjust lamp to have point of copper as near center of reflector as possible.

3. Have carbon in center of chimney hole in reflector.

4. Have locomotive on straight track and move lamp until you get best results on track. The light should be reflected in parallel rays.

To lower light on track, raise lamp.

To raise light on track, lower lamp.

If light throws any shadows it is not focused properly.

If light is focused properly and does not then strike center of track do no change focus, but shift entire case on baseboard.

Point of copper should be about 1 inch above top of holder No. 300. If it is higher than this, there will be too much heat on clutch No. 304.

The following is the approximate focal point of reflectors of following sizes:

16	x	8	inches	2⅜ inches
17½	x	10½	inches	1⅝ inches
18	x	8¾	inches	2 3/16 inches
18	x	9	inches	2¼ inches
18	x	12	inches	1¾ inches
23	x	14	inches	2⅛ inches

ELECTRICAL TERMS EXPLAINED.

As there are many men who have no definite idea of what electricity really is, and as a slight knowledge is necessary to properly care for electric headlight equipment, and to get the best results therefrom, a few extracts from the A B C of electricity, in simple language and terms familiar to nearly all, are here given, so they may be very readily understood, and will be of interest to those using electric headlights.*

*These extracts are taken from the Pyle instruction book, and are necessarily very brief.

Diagram Showing Names and Numbers of Parts for BUDA-ROSS Electric Headlight Equipment

Fig. 1.

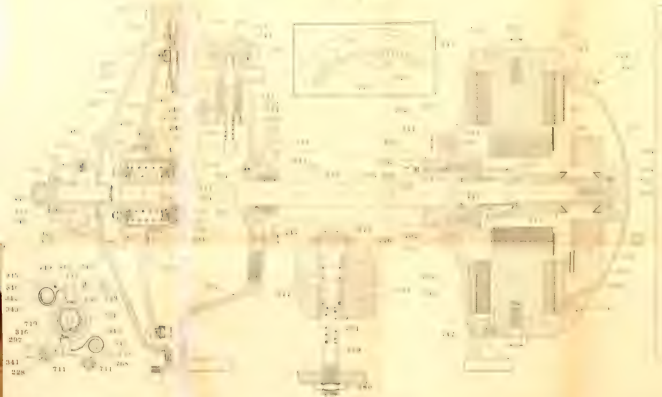
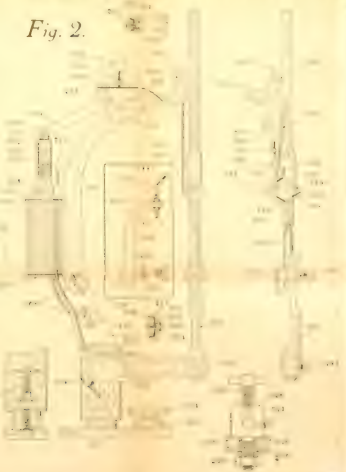
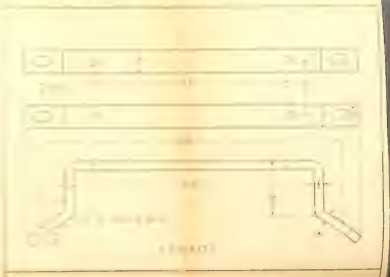
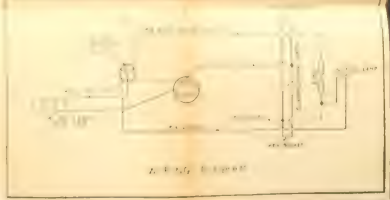
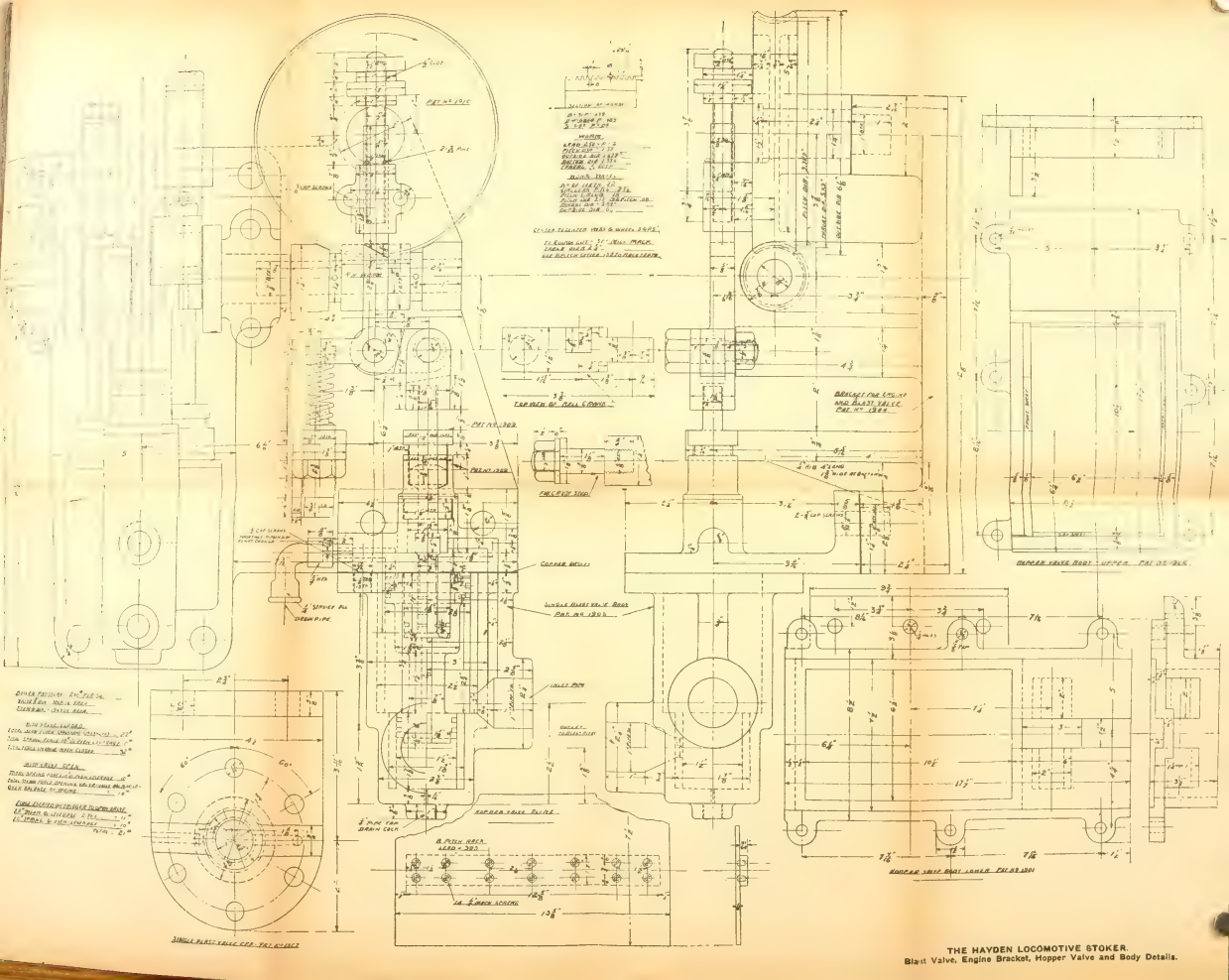


Fig. 2.









THE HAYDEN LOCOMOTIVE STOKER.
Blast Valve, Engine Bracket, Hopper Valve and Body Details.

DEFINITIONS.

The three first measurements in electricity are:

The volt. The ampere. The ohm.

These are explained as follows:

THE VOLT—This term may be better understood by making a comparison with something you all know of. Suppose we have a tank containing 100 gallons of water and we want to discharge it through a half-inch pipe at the bottom of the tank Suppose, further, that we want to make the water spout upward, and for this purpose the pipe is bent upward as in Fig. 5.

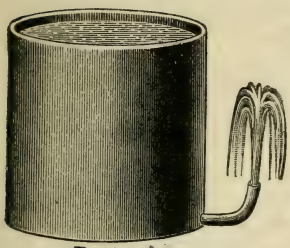


FIG. 5.

If you opened the tap the water would spout out and upward as in Fig. 5. The cause of its spouting upward would be the weight or pressure of the water in the tank This pressure is reckoned as so many pounds to the square inch of water.

Now, if the tank were placed on the roof of a house and the pipe brought to the ground, as shown in Fig. 6, the water would spout up very much higher, because there would be many more pounds of pressure on account of the height of the pipe.

So the force or pressure of water is measured in pounds, and therefore a pound is the unit of pressure or force of water. Now, in electricity the unit of pressure or force is called a volt. This word "volt" does not mean any weight, as the word "pound" weight does. If you have a pound of water you must have something to hold it, because it has weight, and consequently occupies some space. But electricity itself has no weight, and therefore cannot occupy any space.

When we desire to carry water into a house or other building we do so by means of pipes, usually made of iron. The principal supply

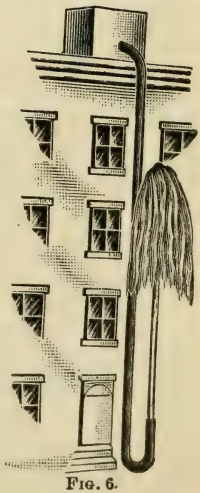


FIG. 6.

usually comes from a reservoir which is placed on high ground so as to give the necessary pounds of pressure to force the water to the upper part of the houses. If some arrangement of this kind were not made we could get no water in our bedrooms, because water will not rise above its own level unless by force.

The water cannot escape as long as there are no holes or leaks in the iron pipes; but if there should be the slightest crevice in them the water will run out.

In electricity we find similar effects.

The electricity is carried into houses by means of wires, which are covered or insulated with various substances—such, for instance, as rubber. Just as the iron of the pipes prevents the water from escaping, the insulation of the wire prevents the escape of the electricity. If we were to cause the pounds of pressure of water in pipes of ordinary thickness to be very greatly increased the pipes could not stand the strain and would burst and the water would escape. So it is with electricity.

If there were too many volts of pressure the insulation would not be sufficient to hold it, and the electricity would escape through the covering or insulation of the wire.

It is a simple and easy matter to stop the flow of water from an ordinary faucet by placing your finger over the opening. As the water cannot then flow, your finger is what we would call a non-conductor, and the water will be retained in the pipe.

The same effect is obtained in the case of electricity. If you place some substance which is practically a non-conductor or insulator, such as rubber, around an electric wire, or in the path of an electric current, the electricity acted upon by the volts of pressure cannot escape, because the insulation keeps it from doing so, just as the iron of the pipe keeps the water from escaping. Thus the volt does not itself represent electricity, but only pressure which forces it through the wire.

There are other words and expressions used in connection with electricity which are sometimes associated with the word volt. These words are pressure and intensity. You might say, for instance, that a certain dynamo machine had an electro-motive force of 110 volts, or that the intensity of a cell of battery was two volts, etc.

We might mention, as another analogy, the pressure of steam in a boiler, which is measured or calculated in pounds, just as a pressure

of water is measured. So you might say that 100 pounds of steam pressure used through the medium of a steam engine to drive a dynamo could thus be changed to electricity at 110 volts pressure.

THE AMPERE—In comparing the pounds pressure of water with volts of pressure of electricity we used as an illustration a tank of water containing 100 gallons, and we saw that this water had a downward force or pressure in pounds. Let us now see what this pressure was acting upon. It was forcing the quantity of water to spout upward through the end of the pipe. The pounds pressure of water acting upon the 100 gallons would force it out at a certain rate, which, let us say, would be one gallon per minute.

This would be the rate of flow of water out of the tank. Thus we find a second measurement to be considered in discharging the water tank. The first was a force or pounds of pressure, and the second the rate at which the quantity of water was being discharged per minute by that pressure.

This second measurement teaches us that a certain quantity will pass out of the pipe in a certain time if the pressure is steady, such quantity depending, of course, on the size or friction resistance of the pipe. In electricity the volts of pressure act so as to force the quantity of current to flow through the wires at a certain rate per second, and the rate at which it flows is measured in amperes. For instance, let us suppose that an electric lamp required a pressure of 100 volts and a current of the ampere to light it up, we should have to supply a current of electricity flowing at the rate of one ampere, acted upon by an electro-motive force of 100 volts.

You will see, therefore, that while the volt does not represent any electricity, but only its pressure, the ampere represents the rate of flow of the current itself.

You should remember that there are several words sometimes used in connection with the word ampere. For instance, we might say that a lamp requires a current of one ampere or that a dynamo would give a "quantity" of twenty amperes.

THE OHM—You have learned that the pressure would discharge the quantity of water at a certain rate through the pipe. Now, suppose we were to fix two discharge pipes to the tank, the water would run away very much quicker, would it not? If we were to try and find a reason for this, we should see that a pipe can only, at a given pressure, admit so much water through it at a time.

Therefore, you see, this pipe would present a certain amount of resistance to the passage of the total quantity of water, and would only allow a limited quantity at once to go through. But if we were to attach two or more pipes to the tank, or one large pipe, we should make it easier for the water to flow, and therefore the total amount of resistance to the passage of water would be very much less and the tank would be quickly emptied.

Water has substance and weight, and therefore occupies some space, but electricity has neither substance nor weight, and therefore cannot occupy any space; consequently to carry electricity from one place to another we do not need to use a pipe which is hollow, but a solid wire.

These solid wires have a certain amount of resistance to the passage of electricity, just as the water pipe has to the water, and (as it is in the case of the water) the effect of the resistance to the passage of electricity is greater if you pass a larger quantity through than a smaller quantity.

If you want to carry a quantity of electricity to a certain distance and for that purpose use a wire, there would be a certain amount of resistance in that wire to the passage of the current through it; but if you use two or more wires of the same size, or one large wire, the resistance would be very much less and the current would flow more easily.

Suppose, instead of emptying the water tank from the roof through the pipe, we just turned the tank over and let the water pour out at once down to the ground. That would dispose of the water very quickly and by a short way, because there would be no resistance to its passage to the ground. Suppose we had an electric battery giving a certain quantity of current, say five amperes, and we should take a large wire that offered no resistance to that quantity, and put it from one side of the battery to the other, a large current would flow at once and tend to exhaust the battery. This is called a short circuit because there is little or no resistance, and it provides the current with an easy path to escape. Electricity always takes the easiest path. It will take as many paths as are offered, but the largest quantity always takes the easiest. As the subject of resistance is one of the most important in electricity, we will give you one more example, because if you can obtain a good understanding of this principle it will help you to comprehend the whole subject. We

started by comparison with a tank holding 100 gallons of water, discharging through a half-inch pipe, and showed you that the pounds of pressure would force the quantity of gallons through the pipe. When the tap was first opened the water would spout up very high, but as the water in the tank became lower the pressure would be less, and consequently the water would not spout up so high; so if it were desired to keep the water spouting up to the height it started with, we should have to keep the tank full so as to have the same pounds pressure all the time. But if you wanted the water to spout still higher we should have to use other means, such as a force pump, to obtain a greater pressure.

If we should use too many pounds pressure it would force the quantity of water more rapidly through the pipe and would cause the water to become heated because of the resistance of the pipe to the passage of that quantity acted upon by so great a pressure. It is the same with electricity, except that the wire itself would become heated, some of the electricity being turned into heat and lost. If the wire were too small for the volts pressure and amperes of current of electricity, the resistance of such wire would be overcome and it would become red-hot and perhaps melt. Electricians are therefore very careful to calculate the resistance of the wires they use before putting them up, especially when they are for electric lighting, in order to make allowances for the amperes of current which flows through them, so that but little of the electricity will be turned into heat and thus render it useless for their purpose.

The unit of resistance is called the "OHM."

All wires have a certain resistance per foot, according to the nature of the metal used and the size of the wire, that is to say, the finer the wire the greater the number of ohm resistance it has to the foot. Water and electricity flow under very similar conditions, that is to say, each of them must have a channel or conductor, and each of them requires pressure to force it onward. Water, however, being a tangible substance, requires a hollow conductor, while electricity being intangible will flow through a solid conductor. The iron of the water pipe and the insulation of the electric wire serve the same purpose, viz.: that of serving to prevent escape by reason of a pressure exerted.

There is another term which should be mentioned in connection with resistance, as they are closely related, and that is opposition.

There is no general electrical term of this name, but as it will be most easily understood from the meaning of the word itself, we have used it.

Let us have an example of what opposition would mean if applied to water. Probably every one knows that a water wheel is a wheel having large paddles or blades around its circumference. When the water in trying to force its passage rests against one of these paddles it meets with opposition, but overcomes it by pushing the paddle away. This brings around more opposition in the shape of another paddle which the water also pushes away, and so this goes on, the water overcoming this opposition and turning the wheel around, by which means we can get the water to do some work for us.

You must remember, however, that it is only by putting opposition in the path of a pressure and quantity of water we can get this work. The same principle holds good in electricity. We make electricity in different ways, and in order to obtain useful work we put in its path the instruments, lamps or machines which offer the proper amount of resistance or opposition to its passage, and thus obtain from this wonderful agent the work we desire to have done. You have learned that the three important measurements in electricity are as follows:

The volt is the practical unit of measurement of pressure.

The ampere is the practical unit of measurement of the rate of flow.

The ohm is the practical unit of measurement of resistance.

PRESSURE REGULATORS OR REDUCING VALVES.

To reduce from a high initial pressure such as is carried on a modern locomotive boiler to a required minimum for steam heating or other similar purposes, and to always maintain this same minimum pressure regardless of the varying conditions on either side of the valve, has always been a problem difficult of solution.

Pressure regulators employing pistons have largely been superseded by those wherein flexible diaphragms are used. The pistons are more liable to stick and clog up, and require to be frequently taken apart and cleaned.

The most perfect regulators thus far constructed are those wherein diaphragms and balanced valves are employed. By making these of proper proportion a comparatively uniform reduced pressure may be maintained, provided the supply and demand are not too suddenly and widely changed.

The reason why a uniform pressure is required in train heating systems is not so much on account of maintaining a uniform temperature (for steam at 30 pounds pressure is but little hotter than steam at 10 or 20 pounds pressure) as it is to keep a constant pressure sufficient to drive out all the condensation from the rear as well as the front cars of a train, and to prevent a high accumulation of pressure which is likely to burst hose, wherever used, or strain the couplings, fittings, etc.

DIRECTIONS FOR THE MANAGEMENT OF STEAM HEATING ON RAILROAD TRAINS.

Rules for Making up Trains.—When a train is made up, all steam hose should be coupled, and all the cocks in the steam train pipe the whole length of the train should be opened.

When signal is given, steam should be turned on at the cab, not to exceed sixty-five pounds, and allowed to blow through the entire length of the steam train-pipe.

After steam issues at the rear end of the train-pipe, the rear cock of last car should be closed, and reducing valve in cab set to forty pounds pressure. If more than eight cars are in the train, add five pounds for each additional car. In very cold weather, the rear train-pipe cock should be left open enough to allow a little steam to pass, and escape through the rear coupling.

Regulation of Temperature.—To heat cars, open steam inlet valves on each car, and when live steam appears at the drips, set each drip so that a little steam escapes with the water. If a trap be used, see that it is adjusted to allow a little steam to escape with the water.

Frequently examine traps and drip valves to see that they are operating properly. They should be as hot as can be borne by the hand. If cooler, or cold, they should be opened a trifle, or if steam is blowing, closed a little.

Never close steam inlet valves entirely without first opening drip valves or blow-off valve, and allow all water to blow out before closing steam inlet valve.

When steam is required on a car again, open steam inlet valve and afterwards close drip valves or blow-off valve.

Changing Engines.—When approaching stations where engines are to be changed, or terminals where cars are to be laid up, five minutes before arriving at such stations the rear train-pipe cock must be opened wide, and before coming to a stop at such stations, the engineer must shut off steam at boiler valve. Do not use reducing valve for this purpose.

If engines are to be changed, trainmen must satisfy themselves that steam is shut off at engine before uncoupling cars.

In freezing weather, if cars are to be laid up, or stand thirty minutes after engine is uncoupled, the hose throughout the train must be uncoupled, and all drip valves or blow-off valves opened.

THE MASON LOCOMOTIVE REDUCING VALVE.

This valve is designed to automatically reduce and maintain an even steam pressure for heating cars from the locomotive. It is placed in the steam supply pipe leading from the boiler to the heating system and regulates the amount of steam passing to the system, allowing only sufficient steam to maintain the desired pressure.

The principle upon which the Mason reducing valve works is that of an auxiliary valve, 11, controlled by the low pressure in the heating system through the medium of a metal diaphragm (23), and admits steam

from the initial side of the valve, through a port (*NN*) to operate a piston (17), which in turn opens the main valve (16) and admits steam to the heating system.

By referring to the sectional view here shown, it

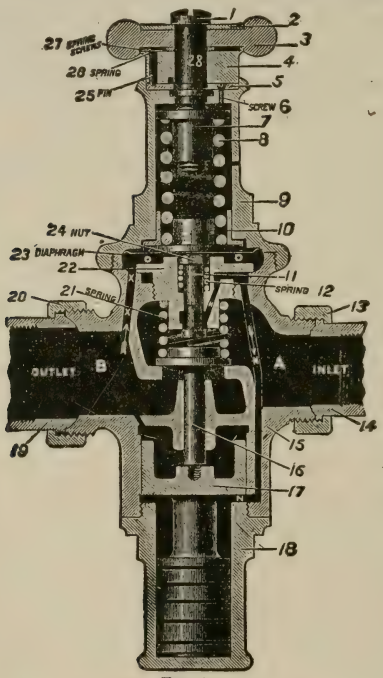


FIG. 1.
Mason Locomotive Pressure Reducing Valve.

will be seen that the steam enters the valve at the side marked "inlet," a small portion of it passing up through the auxiliary valve (11).

This valve (11) is forced open by the compression of the large spiral spring (8), acting on the button (10)

through the diaphragm (23), so that, in opening the valve (11), the diaphragm is also forced down. As soon as the valve (11) is opened, steam passes through and into ports (*N N*) to the under side of piston (17). By raising piston (17), the main valve (16) is opened against the inlet pressure, since the area of valve (16) is only half that of piston (17). Steam is thus admitted to the system. When the pressure in the heating system has reached the required point, which is determined by the spring (8), the diaphragm (23) is forced upward by the low pressure which passes up through port (*X*) to chamber *O O*, under the diaphragm, thus allowing auxiliary valve (11) to close, thereby shutting off steam from the under side of piston (17). The main valve (16) is now forced down to its seat by the inlet pressure, shutting off steam from the heating system and pushing piston (17) down to the bottom of its cylinder. The steam beneath piston (17) exhausts freely around it (the piston being fitted loosely for this purpose) and passes off into the system.

It will be seen from this that when the pressure in the heating system has reached the point at which the governing spring (8) is adjusted, the flow of steam is automatically checked, and when the pressure in the system (and that in chamber *O O*, under the diaphragm,) is slightly reduced, the valve will again open and supply the required amount of steam.

Piston (17) is fitted with a dashpot (18), which prevents chattering or pounding when the pressure is suddenly reduced.

Directions for Attaching, Regulating and Repairing.—Place the valve vertically in the steam supply

pipe. The steam should flow through the valve in the direction indicated by the arrow cast in the side. Before connecting the valve, the pipes should be thoroughly blown out, in order to expel all dirt and chips. If the piping is new, steam should be allowed to flow through for some little time, so as to burn off all the oil or grease which may be in it.

When ready to let on steam, turn the wheel at top of the valve in the same direction as you would to open a globe valve; that is, turn to the left to open or admit more steam and to the right to close or reduce the pressure. Time must be allowed for the system to fill, before the required pressure is obtained.

If the valve should not maintain a low pressure, it will probably be due to the fact that some dirt or chips from the piping have lodged in the seat of the valve (16).

To take the valve apart, the tension on the diaphragm spring (8) must first be removed by turning the wheel as far as it will go, in the direction taken by the hands of a watch. Then unscrew the spring-case (9), and remove the button (10) and the diaphragm; also remove the cap (22), which contains the auxiliary valve. The threaded rod which accompanies each valve can then be screwed into the valve disc (16), which should work easily. Pull out this valve and clean the seat. Then insert the rod through the valve-stem hole, screw it into the piston (17), and see if it works up and down easily. It will not be found possible to raise and lower the piston (17) suddenly, as the dashpot (18) will restrain it. If the piston (17) is found to be stuck fast, remove the dashpot (18) at the bottom of the valve, pull out the piston

and clean it with fine emery cloth; being careful to wipe off all emery before replacing. Before replacing the cap (22), examine the small auxiliary valve (11) and see that it is tight and free from dirt. Be sure that the diaphragm (23) is perfectly clean, also that there is no dirt where it makes its seat.

The wheel is made self-locking in any position, by means of a steel locking pin (25), which is forced by a spring into any one of twelve recesses in a hardened steel plate (5). The valve should be removed during the summer. Before replacing, thoroughly clean and oil all the parts.

THE GOLD PRESSURE REGULATOR.

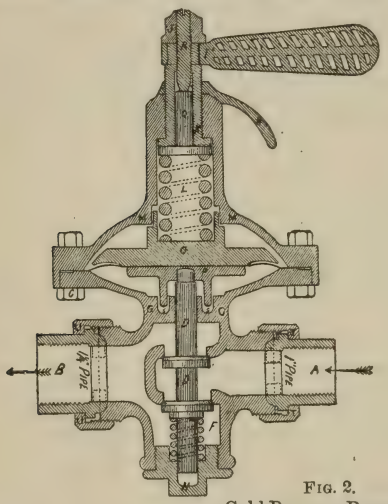
Fig. 2 shows a sectional view of the Gold steam heating regulator. It will be readily seen that this is of the diaphragm type with a nearly balanced valve.

The diaphragm is made of a solid sheet of thin phosphor bronze, slightly corrugated at the outer edge, with an enlarged flange (*O*), so that the diaphragm will always keep its original shape. The dome (*M*) of the regulator is solid so that no steam would escape into the cab should the diaphragm break. The recess shown at *S S* provides a water seal in order to prevent any chattering of the valve.

The regulator is set by means of the handle (*I*), which is perforated in order to keep it cool for easy handling by the engineer. The handle (*N*) is an extension of a lock nut which holds the regulating screw firmly in any given position. The set screw (*R*) is provided as a check on the maximum or minimum amount of pressure required as it can be seen

that the play of the spring (L) is controlled by this set screw (R). Spring (F) helps to guide the spindle (D D) and also tends to more nearly balance the valves and make up for any possible gumming of valves or spindle.

Main valve D D is opened and closed by the movement of the diaphragm. Spring L forces



PARTS OF REGULATOR.

A.—1 inch Inlet Union Nipple.
B.—1¼ inch Outlet Union Nipple.
C.—Bolts and Nuts for Dome and Body.
D.—Balance Spindle with Hard Seats.
F.—Bottom Spring.
G.—Body of Regulator.
H.—Bottom Plug.
I.—Handle.
J.—Top Nut.
K.—Hollow Screw.
L.—Top Spring.
M.—Dome of Regulator.
N.—Lock Nut.
O.—Top Flange.
P.—Bottom Flange.
Q.—Top Spindle
R.—Set Screw.
T.—1 inch Inlet Union Nut.
U.—1¼ inch Outlet Union Nut.

FIG. 2.
Gold Pressure Regulator.

the diaphragm down and the main valve opens and remains thus until steam from the outlet side of the valve, some of which passes the loose stem D to the under side of the diaphragm, closes the main valve.

CLIMAX STEAM PRESSURE REGULATING VALVE.

Description.—Steam enters at A, surrounds main valve (1), passes the water packing grooves around this valve, and bearing against the shoulder carries

this valve (1) upward, allowing steam to pass through the now raised valve to *B*, as shown by the arrows. The reduced pressure steam from *B* also acts upward through ports (3 and 11) upon the under side of regulating piston (6). If spring (7) were set for say 100 pounds, as soon as the pressure on the under side

1 Main Valve.
2 Opening in Main Valve.
3 Port Leading to the Regulating Piston 6.
4 Solid Disc, held in place by Cap 12.
6 Regulating Piston.
7. Regulating Spring.
8 Regulating Screw.
10 Auxiliary Valve Spring.
11 Ports in Disc 4.
12 Governor Cap.
13 Controlling Steam Chamber.
14 Body.
16 Auxiliary Valve.

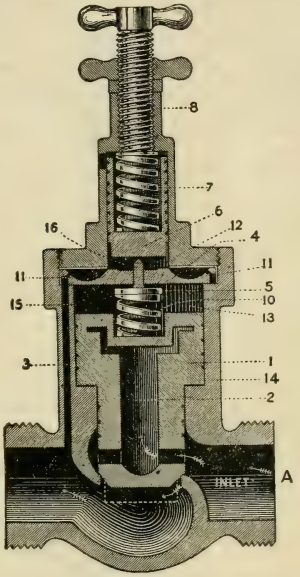


Fig. 3.
Climax Steam Pressure Regulating Valve.

of regulating piston (6) reached that amount, it would move slightly upward and away from its former contact with the auxiliary valve (16), thus allowing 16 to seat in disc (4), thereby preventing the further escape of steam from the controlling chamber (13). Steam from inlet (*A*) passing through the grooves or water packing of valve (1) to chamber (13), now seats

valve (1) until the pressure at *B* and consequently that below piston (6), drops slightly below 100 pounds. Then spring (7) forces down piston (6) and opens auxiliary valve (16), thereby permitting the escape of pressure from chamber (13) through valve (16), ports (11 and 3) to *B*. The conditions are such now, as in starting, that valve (1) is raised for a further supply of steam from *A* to *B*. In actual operation, where a continuous flow is being used, valves (1 and 16) are held just sufficiently off their seats to maintain a uniform pressure at *B*.

The valve shown in the cut is intended for use where a large and continuous supply of steam is needed, as for running dynamos for train lighting, etc. When this valve is to be used for train heating only, a projection is made on the bottom of valve (1), as shown by the heavy dotted line, so that only a small annular opening is made as the valve starts from its seat.

To obtain greater pressure screw down on the spring (7) by means of the regulating screw (8). To obtain less pressure screw up on the regulating screw.

ECLIPSE REDUCING VALVE.

Description.—Before starting, spring (*A*) and the stem below it have forced down piston (*B*) and opened valves (*E E*). When steam is turned on at the steam heat throttle valve on the boiler head and as soon as the reduced pressure at the left hand or outlet side which also acts on the under side of piston (*B*) has reached a sufficient amount to over-balance the tension in spring (*A*) , the piston (*B*) will raise and pull

with it the valves (*E E*), thereby shutting off any further supply of steam until the pressure under piston (*B*) again falls below the tension of spring (*A*). In action this valve does not open wide and then close, but assumes a position open only enough to admit a uniform supply of steam needed to maintain the desired pressure.

A. Regulating Spring and Stem.
B. Regulating Piston.
C. Exhaust Pipe to Atmosphere.
D–D. Relief Ports.
E–E. Double Seated Valve.
F. Regulating Screw.
G. Lock Nut.
I. Inlet.
O. Outlet.

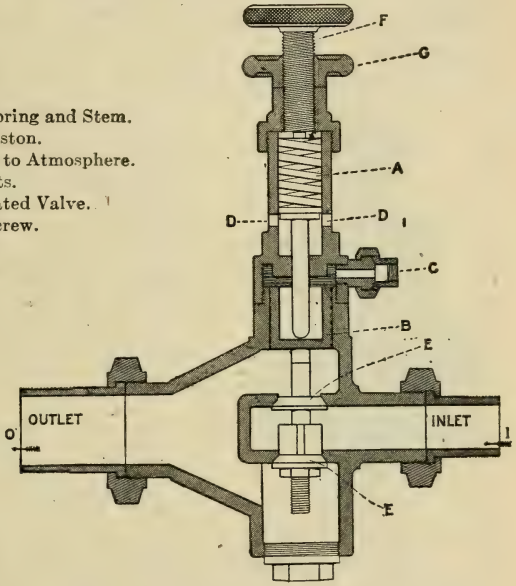


FIG. 4.
Eclipse Reducing Valve.

This reducing valve is also made with a double piston valve in place of the double bevel seated valves (*E E*), but the latter, as shown in the engraving, is more satisfactory, especially for short trains requiring but small supply of steam.

To obtain greater pressure screw down on *F* and lock with *G*, or do the reverse if less pressure is desired.

THE TAAFEL PRESSURE REGULATOR.

This regulator, sometimes called the "Leslie" regulator, is used largely on locomotives for train heating.

The engraving here shown gives a sectional view through the center of the valve, whose operation is as follows:

Steam from the inlet side (*R*) enters from the right

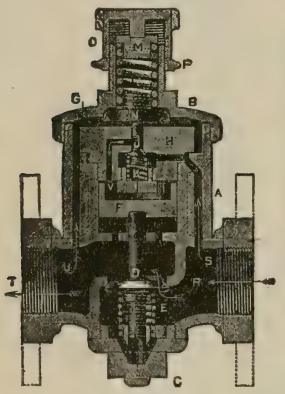


FIG. 5.
Taafel Pressure Regulator.

A. Main Body.
B. Top Cap of Main Body.
C. Bottom Cap of Main Body.
D. Main Valve.
E. Main Valve Spring.
F. Piston.
G. Diaphragm.
H. Body of Regulating Valve.
I. Cap of Regulating Valve.
J. Regulating Valve.
K. Regulating Valve Spring.
L. Adjusting Spring.
M. Top Seat of Adjusting Spring.
N. Bottom Seat of Adjusting Spring.
O. Regulating Cap.
P. Lock Nut of Regulating Cap.
Q. Wood Handle and Nut.
R Inlet.
S. Inlet Port to Reg. Valve Chamber.
T. Outlet.
U. Port to Diaphragm Chamber.
V. Port from Regulating Valve Chamber to Piston Chamber.

hand side, as shown in the cut. A portion of the steam passes up through port (*S*) to the regulating valve (*J*) which it finds open, due to the downward pressure of the adjusting spring (*L*) on the diaphragm (*G*), which in turn bears upon the small valve (*J*). This small regulating valve being open allows the steam to pass as shown by the arrow to chamber (*V*) where it forces piston (*F*) downward, thus opening

the main valve (*D*) and allowing steam from the locomotive boiler to pass to the train heating system at the outlet (*T*). Port (*U*) connects the under side of diaphragm (*G*) with the heating system, and when the pressure there reaches whatever amount the adjusting spring (*L*) is set to withstand, the slightest additional pressure will cause diaphragm (*G*) to bend upward enough to release regulating valve (*J*), thus allowing the latter to be seated by the force of its spring (*K*), just beneath it. No further supply of steam from the inlet side can now reach chamber (*V*) and what pressure remains therein can pass around piston *F* (which is for this purpose but loosely fitted in its cylinder) and equalize with the system pressure underneath. Piston (*F*), being equally balanced, permits the main valve spring (*E*) to close the main valve (*D*), thereby shutting off further supply of steam to the heating system.

As soon as the pressure of the steam in the heating system under diaphragm (*G*) becomes the least amount less than that of the adjusting spring (*L*), the diaphragm will bulge downwards, unseating regulating valve (*J*), which, as before described, again produces a supply of steam to the system.

For attaching and adjusting this regulator the following directions should be observed:

When possible place regulator in a vertical position on a horizontal pipe, but always arranged so the steam will pass through in the direction indicated by the arrow cast on the side of the valve body.

Before attaching the regulator put a stop valve on inlet pipe and blow out pipes thoroughly; after the regulator has been attached and before pressure is

turned on, unscrew cap (*O*) to take all pressure off the adjusting spring (*L*). Open the stop value, then screw down the regulating cap (*O*) until the desired pressure is reached, when the cap should be locked in position by lock nut (*P*). A very slight turn of the cap either way will change the pressure.

The regulating cap (*O*) can be removed while pressure is on, if so desired.

The top cap (*B*) of main body can be removed while pressure is on, providing steam is released from the outlet pipe (*T*).

The diaphragm must always be set with bead up.

To take out main valve (*D*), unscrew the bottom cap (*C*) of the main body.

To remove the regulating valves, first unscrew top cap (*B*) of main body, then unscrew the regulating valve body (*H*), and also cap (*I*).

When repairing, care should be taken to see that all joints, seats and piston are thoroughly cleaned and a little heavy oil used on the joints before screwing them up tight.

Never use oil of any kind on the piston, valves, valve seats or valve stems.

When the regulator is in working order all parts should work freely.

All parts of each size regulator are interchangeable.

THE ROSS STEAM PRESSURE REDUCING VALVE.

This reducing valve shown in the accompanying cut is of the diaphragm-piston type. The regulating screw at the top produces the required pressure through a double coil spring upon a flexible metallic

diaphragm having a stem extending down by a loose fit through the regulating piston and supply valve to an adjusting nut.

This adjusting nut regulates the maximum opening of the supply valve, which opening should not be over $\frac{1}{8}$ inch, and the stem serves as a guide to the piston and valve, which are in one piece. As the stem is a loose fit in the latter, the pressure beneath the supply valve (that of the heating system) and that in the small chamber between the diaphragm and the piston are always the same. Hence, when steam from the locomotive boiler (entering from the right as shown in the engraving) strikes the upper side of the valve and the under side of the piston, as there is no pressure on top of the latter due to the asbestos packing (shown in the illustration by dark lines) therein, the valve is forced down and open, admitting steam to the heating system. When the pressure in the heating system, passing by the stem to the under side of the diaphragm, becomes great enough, it causes the dia-

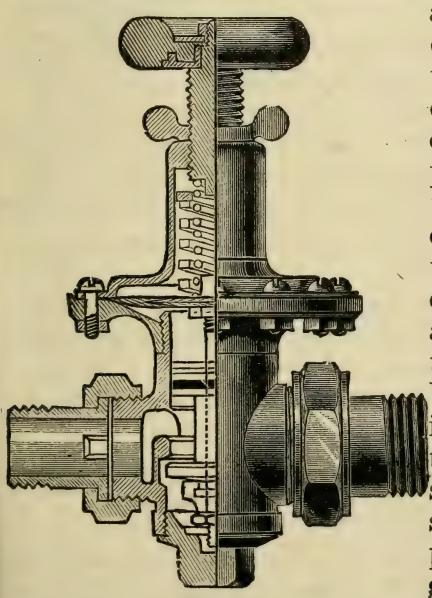


Fig. 6.
Ross Steam Pressure Reducing Valve.

phragm to raise sufficiently to clamp the valve to its seat and shut off further supply until the system pressure reduces below the set limit. When that condition again exists, the diaphragm springs downward allowing the supply valve to again open.

Adjustment and Repairs.—The piston should always be kept well packed with asbestos, the diaphragm joint kept tight, and the adjusting nut on the bottom of the stem set so that valve cannot open more than $\frac{1}{8}$ inch.

If steam in large quantities passes the valve when it should not, take off the bottom cap, unscrew the adjusting and yoke nuts, pull out the valve and piston.

If the valve has a good seat and no scale or dirt is found under it, the trouble was due to the valve having too much lift. Hence, in replacing the parts, screw the adjusting nut up until the valve is clamped to its seat, first having relieved tension on the diaphragm from the top regulating screw; then slack off the nut about a turn and a half or two turns and the trouble will be overcome.

If the valve regulates well on long trains, or where much steam is used, but allows the pressure to become too great on short trains, or where the steam requirements are small, the piston packing has become hardened or worn out and should be replaced.

SPECIAL AUTOMATIC RELIEF VALVE.

The Consolidated Car Heating Company employ the Mason regulator or reducing valve, which has been fully described elsewhere, and also, for addi-

tional safety, the special relief valve shown sectioned in the accompanying cut, Fig. 7.

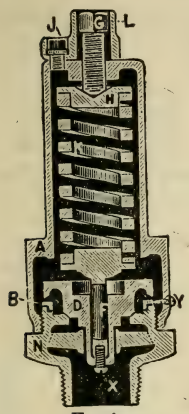


FIG. 7.
Special Automatic Relief Valve.

This relief valve is set at 50 pounds and is for the purpose of relieving the pressure in system heating pipe and at the same time signaling the engineer, should the pressure become too great.

By its use the not infrequent delays due to hose burst from over-pressure may be reduced to a minimum.

To take valve apart: Use the key to unscrew lock-screw (*J*), take off the shield (*L*), and relieve the load on spring by unscrewing the set-screw (*G*). Then loosen set-screw (*Y*), and unscrew the casing.

To set valve at a higher pressure: Screw set-screw (*G*) down; at a lower pressure, screw set-screw up.

To regulate pop: The pop or action of the escaping steam is regulated by the externally threaded ring (*B*) in the base of the valve, which is easily accessible without taking valve apart, and is held securely in place when set, by means of set-screw (*Y*) on the side of the valve body. If the valve pops too suddenly and reduces the pressure too much, turn ring (*B*) down (further away from the valve disc), and if it does not pop enough, opening and closing only gradually, turn ring (*B*) up (nearer to the valve disc). When the desired adjustment is obtained, secure the ring by means of the set-screw (*Y*); whenever set-screw (*G*) is changed, the pop regulating ring must in most cases be changed to suit.

To insure proper working: Pop safety valves should be attached immediately upon the boiler, or as close to same as possible; otherwise the connecting pipe should be at least one size larger in diameter than the size of the pop valve.

Caution: Before attaching valve, blow out pipe and avoid the use of too much lead or pipe grease. This valve is sensitive, and any foreign substance lodging in it will prevent its perfect working.

The location of the automatic relief valve and the other locomotive cab attachments connected with the train steam heating apparatus are clearly shown in Fig. 8.

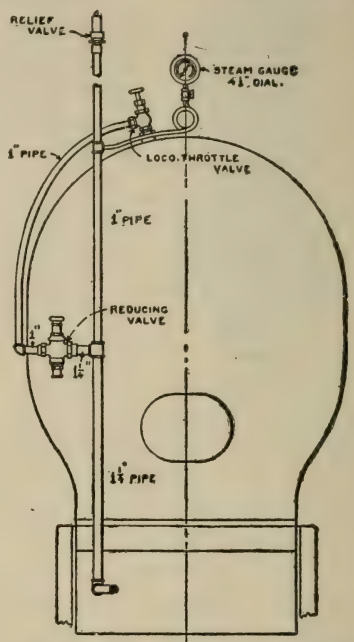


FIG. 8. Location of Steam Heating Cab Attachments.

RULES FOR ENGINEERS.

The following rules are applicable to all forms of direct train steam heating apparatus :

1. Engineers must give for heating trains on the road a steam pressure of twenty pounds, on heating gauge in cab, for trains of five cars, and an additional three pounds for each additional steam-heated car.

2. Give extra pressure up to forty-five pounds, if desired, to heat cold trains, and to blow out at terminal points, before shutting off.

3. Steam must not be shut off from heating apparatus or turned down while on the road.

4. Pressure should always be regulated by the reducing valve, the throttle valve being wide open when using steam for heating. If at any time the reducing valve fails to hold the pressure steady, report same and see that the valve is cleaned.

5. See that the throttle valve of heating apparatus is closed about three minutes before entering stations, where engine is to be disconnected or additional cars to be placed in train, and at terminal points. This is important to prevent scalding train men in uncoupling hose while pressure is on.

6. When not using steam on train, allow sufficient steam to pass through steam pipe to prevent freezing steam pipe under tank.

7. Get signal that steam is through train line before leaving terminal point or changing station.

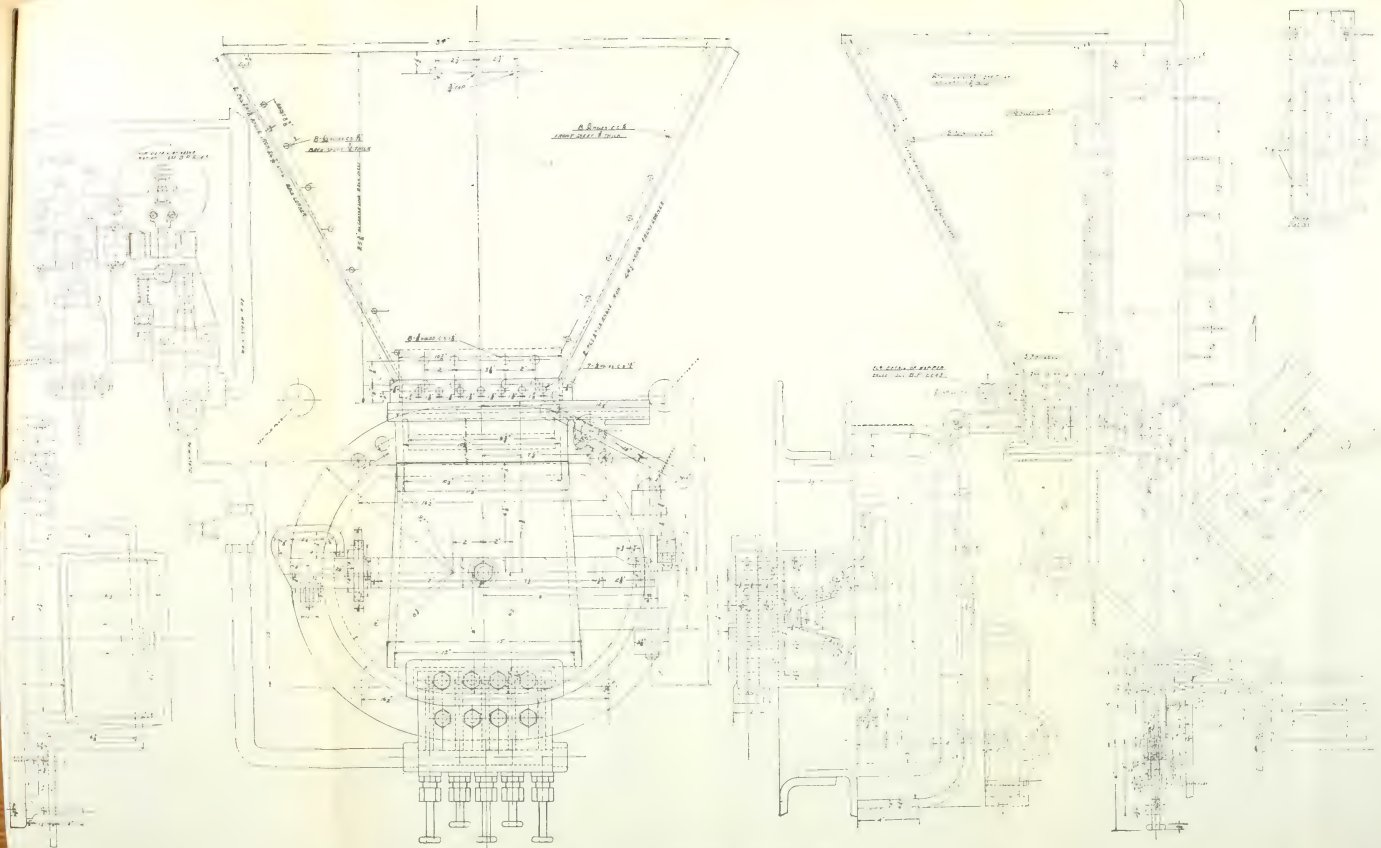
MECHANICAL STOKERS.

In consequence of the increased capacity of modern locomotives involving a proportionate increase in fuel used, thus making the labor of the fireman extremely arduous, the question of the adoption of some mechanical means of firing, thereby lightening the labor of the fireman, and reducing, if possible, the consumption of fuel, has received much consideration, and various devices known as mechanical stokers have been adopted, and for some of them complete success is claimed.

All of the mechanical stokers so far used are very similar in operation, and the following descriptions of the operation of what are known as the "Hayden" and "Strouse" Stokers may in a sense be taken as typical:

Hayden Stoker.

The coal is taken from the tank by an elevator through a grating with 3-inch openings operated by a quadruplex engine; then passes into a conveyor and is elevated to the conveyor located over the fireman's head and is dropped into a hopper over the fire-box door by a worm screw and falls by gravity through a slide-gate opening in the top of the fire-box door on a table located just inside the fire-box door, twenty-four inches long and seven inches wide, and is blown by a blast of steam varying in length as desired



THE HAYDEN LOCOMOTIVE STOKER.

by five separate nozzles or jets in the fire-box door, which have a tendency to cool the table and prevent its burning out. The center jet blows the coal toward the flue-sheet. The next two jets on either side are located to place the coal in the front corners of the fire-box. The two outside jets are located so that the coal will be distributed along the sides and the back corners of the fire-box. They are governed by separate valves to regulate the blast of steam through each valve by common steam valves, and can be adjusted at will at any time.

The steam that furnishes the blast to place the coal is controlled by a quadruplex engine located on the back end of the boiler butt, which has a crank movement actuated by a screw wheel, operating a control valve, which admits steam through a 1-inch pipe passing to the nozzles which are regulated by means of a globe valve. The control valve, as a general proposition, is only run one turn open, and varies with the weight and amount of coal to be handled. The length of blast is governed largely by the raising or lowering of the latch on the trip valve and the rapidity at which the engine is run. The faster the engine is run, the less coal is thrown at one blast. If desired, the valve can be tripped by hand and all of the coal in the hopper can be blown into the fire-box. In fact, the fire can be covered black inside of half a minute.

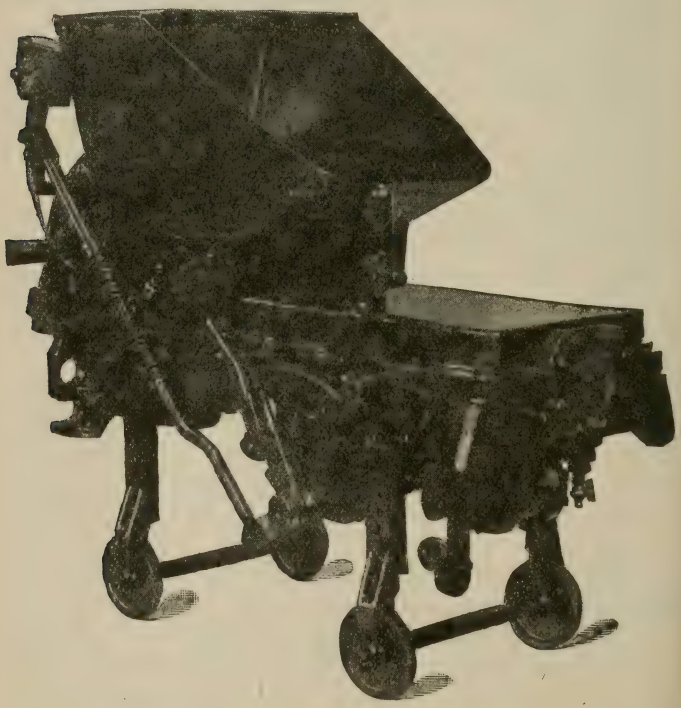
The steam connection to the engine operating the stoker conveyor is by 1-inch pipes; the steam connection operating the stoker engine is by $\frac{3}{8}$-inch pipe, which is only open probably a quarter of a turn.

7. They keep the cold air out of the fire-box, saving repairs and producing better combustion.

8. They keep the fire clean, bright and uniform, preventing clinkers and allowing much longer runs to be made without pulling the fire.

9. They keep the steam pressure up and more uniform than with hand firing, producing all the steam that the engine requires.

10. They do not take the place of the firemen, but reduce their work and assist them in properly firing the engines under all conditions.



11. They save from 10 to 20 per cent of fuel, and, because of the better combustion, also reduce the quantity of smoke produced.

They carry a lighter fire, which requires less draft, and permit the use of a larger nozzle, thus making a large saving in coal by reducing the back pressure.

12. They are easily, cheaply and quickly attached or detached.

13. They do not interfere with the easy inspection of the fire.

14. They fit every type of locomotive.

15. They are self-contained, having no attachments.

16. They do not cause steam to enter the firebox.

17. The stoker fire-door swings entirely clear without removing stoker.

18. No parts of stoker are fixed inside the firebox to warp out of shape.

19. They do not tire the firemen, but enable them to fire the engine at the end of the run as perfectly as at the start.

7. They keep the cold air out of the fire-box, saving repairs and producing better combustion.

8. They keep the fire clean, bright and uniform, preventing clinkers and allowing much longer runs to be made without pulling the fire.

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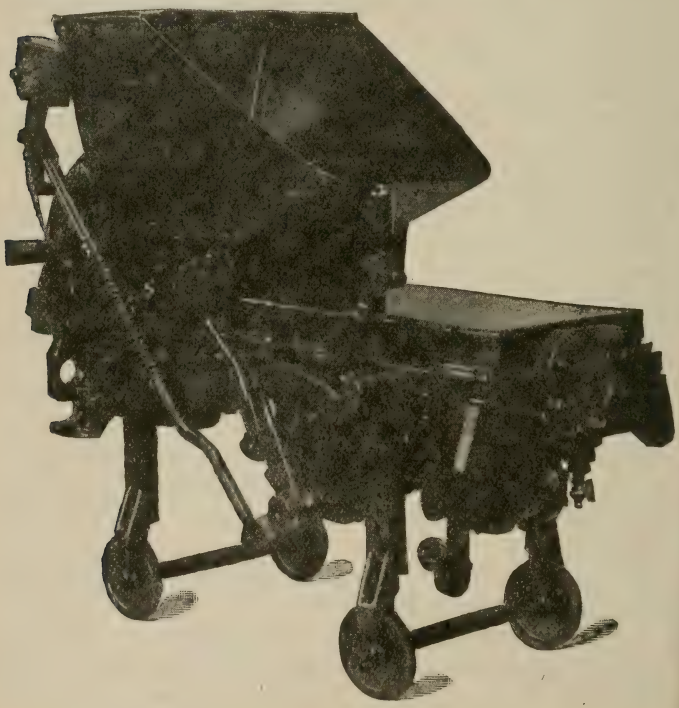

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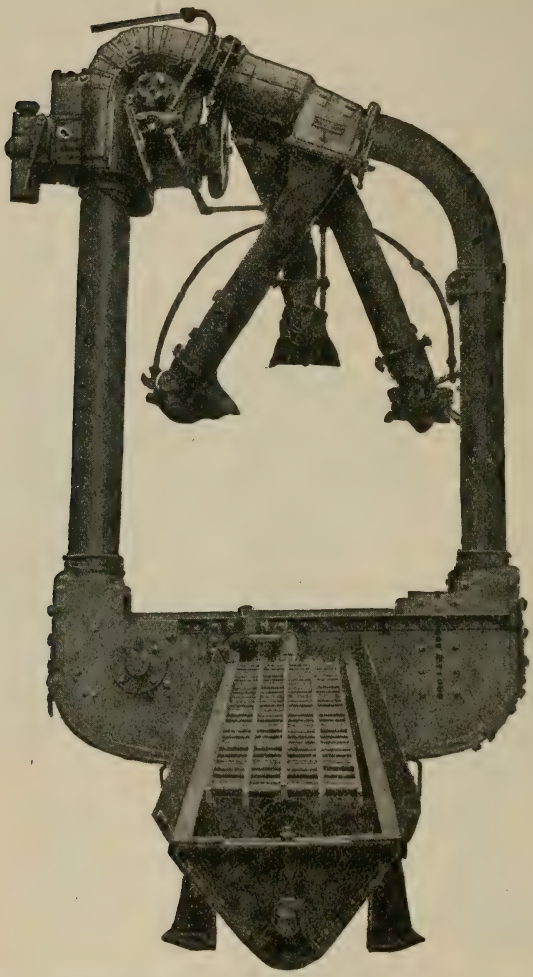

Fig. 1—General Front View of Street Locomotive Stoker

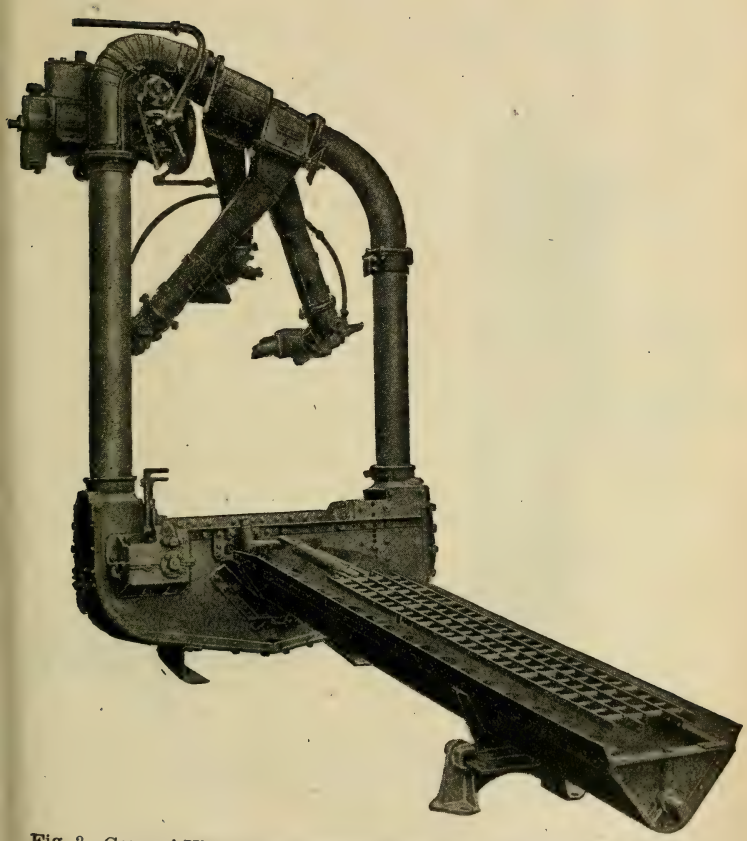

Fig. 2—General View Street Locomotive Stoker, Showing Screw Conveyor, and 4x3½, Variable-Speed Elevator Engine

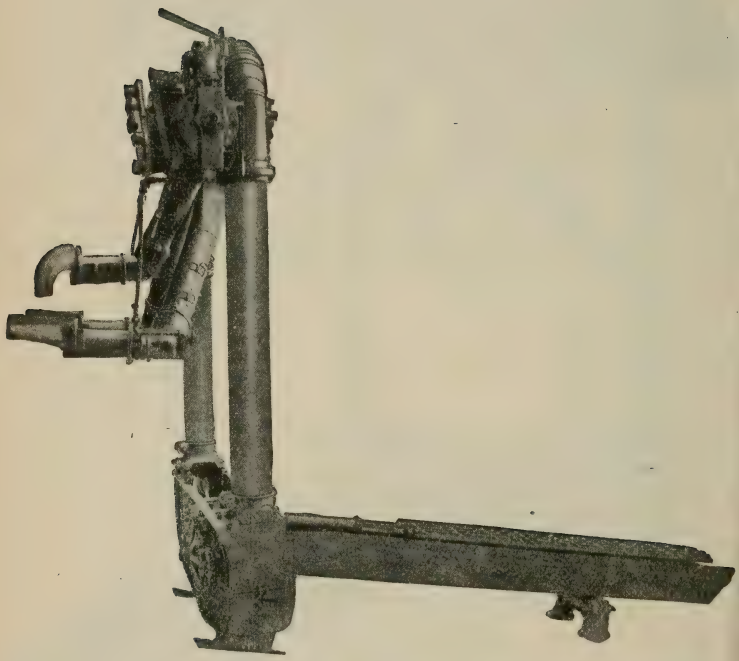

Fig. 3—General Side View of Street Locomotive Stoker Showing Position of Distributers, also Link Belt Drive to Conveyor

THE STREET LOCOMOTIVE STOKER

The Street Locomotive Stoker is shown in general Figs. 1, 2, and 3. It consists essentially of:—

A *Screw Conveyor* for carrying the coal from the tender to the locomotive in such quantity as may be required, as regulated by size of coal opening used over the screen and the speed of stoker as regulated at any one of the seven notches on the variable-speed governor lever quadrant.

An *Elevator* on back-head of boiler for receiving the coal and elevating it to the Discharge Pipe or distributing center.

A *Regulating System* which re-screens the coal and furnishes proper quantities for each firing zone.

A *Distributing System* for spreading the coal over the grate area as may be required to maintain an even fire and maximum steam pressure under the direction of the fireman.

The distribution is secured by means of a *Blast Device* consisting of a *Controller Valve* operated by a set of *Cams*, carried by the worm wheel shaft, and the necessary *Elbows* with jet nozzles, *Distributer Tubes* and *Distributers*.

Method of Operation.—In firing with the stoker the practice is to build up a good fire by hand and get up full steam pressure before leaving a terminal, and not bring the stoker into use until the locomotive is working steam. The fireman then starts elevator engine and opens first coal slide over screen of screw conveyor. The variable-speed governor lever is then placed in middle position and pulling the friction clutch lever puts the entire stoker apparatus into operation.

The screw conveyor is designed to furnish the amount of coal required under average conditions when stoker engine is running at or below medium speed.

The controller lever latch is usually left in contact with

the controller valve stem so that the blast jets will start with stoker when clutch is pulled in. This prevents coal accumulating in distributer pipes.

One or more cams are also left out on the cam head. The small cams open the jets for short periods and place the coal at back of or part way down fire-box, whereas the large cams open the jets for longer periods, allowing more pressure to build up at jet, and thus force coal further forward or completely to front area in fire-box. The usual method is to turn out three cams: one each of small, medium and large.

The automatic movement of screen under the coal opening will cause coal to enter conveyor trough, the helicoid screw will convey coal to elevator hopper and elevator buckets will elevate the coal to the discharge pipe or distribution center.

The finest coal is then screened in proper proportion as determined by size of openings the fireman turns to register in discharge pipe screen.

The fine coal goes down center distributer pipe and is fired by the steam jet from nozzle in center elbow into the fire-box against the center distributer which deflects the fine coal downward and spreads same over the central back part of fire-box.

The coarser coal is carried past the discharge pipe screen by the elevator buckets and falls through large opening in right hand part of discharge pipe and is divided equally, or unequally as may be determined by the fireman, between the two side distributer pipes. The coarse coal is fired by the steam jets in right and left elbows into fire-box and is spread by right and left distributers over the main right and left fire-box areas. The distribution overlaps as between the three areas or zones fired from the three elbows. This overlapping insures ample coal being supplied to center of fire-box in heaviest combustion area.

The deflecting ribs on side distributers, as shown in Fig. 40, place some of the coarser coal in right and left hand back corners of firebox. The fireman can direct more or less coal to each side of the fire-box by changing position of dividing

vane, as shown in end view of discharge pipe, Fig. 31, by moving vane regulating lever up or down, and can place more or less coal in central back portion of fire-box by turning large or small openings to register at bottom of discharge pipe screen, a regulating lever being provided for ready adjustment of this screen to register the different openings as shown in Fig. 28.

The sliding plates at the bottom of the tank are located so that there will be a supply of coal at all times on top of the screw. These plates, however, should never be drawn out so as to bury the screw entirely in coal; for, if this is done, it is difficult to see just how the coal is feeding.

As coal is used from tender so that it no longer flows freely through first slide opening then fireman opens next slide and so on until supply is again taken at coal chute; then slides are all pushed back and first slide opening used as in starting out.

With the distribution as described, a level, light fire can be carried by fireman and perfect combustion secured. This level, thin fire usually results in the fire-box temperature being four or five hundred degrees higher than with hand firing.

Stoker Motor.—The apparatus is driven by a 4 x 3½ *Variable-speed Elevator Engine* bolted to bracket on back-head of boiler and operated by steam taken from boiler at gauge pressure. The *Elevator Engine operates* at speeds varying from 400 to 600 revolutions per minute, and drives the stoker by a 20 to 1 worm gear which transmits the power to the Elevator Chain through the Sprocket Wheel Casing.

The *Elevator Chain* drives a sprocket and shaft in elevator hopper at bottom of stoker which in turn operates the eccentric attached to the bell crank of coal screen, and this lower driven elevator chain sprocket shaft also carries another sprocket on front of hopper which drives the helicoid screw conveyor as shown in Figs. 3, 25 and 26.

Variable-Speed Elevator Engine—4 x 3½. The elevator engine is of the single acting type, running at speeds of 400

to 600 revolutions per minute, and is controlled by a shaft governor inside of crank case running in oil and regulating the valve cut-off.

The governor has an outside lever with quadrant as shown in Fig. 4, which permits setting the engine speed at any one

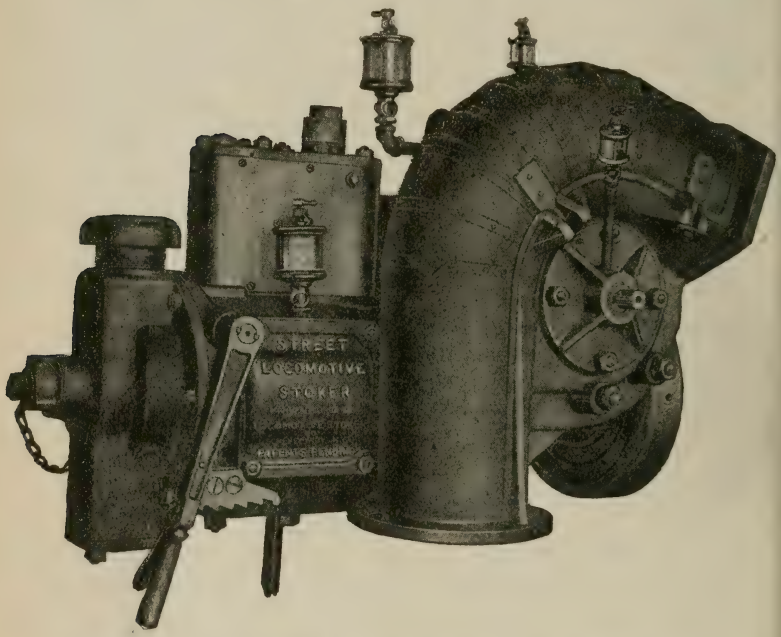

Fig. 4—Front View of 4x3½ Variable-Speed Elevator Engine, Complete with Friction Clutch, Sprocket Wheel Casing, Variable-Speed Governor Lever and Quadrant

of seven speeds, which are constant at each notch of the governor control.

The Sprocket Wheel Casing, to which the Elevator Engine is attached, also carries the special Friction Clutch and lever connections as shown in Fig. 6.

The engine is oiled from two sources; a splash system, con-

sisting of oil film on water level in crank case, and by oil reaching the engine cylinder through the steam line from tap to main locomotive lubricator. The splash system oil level is

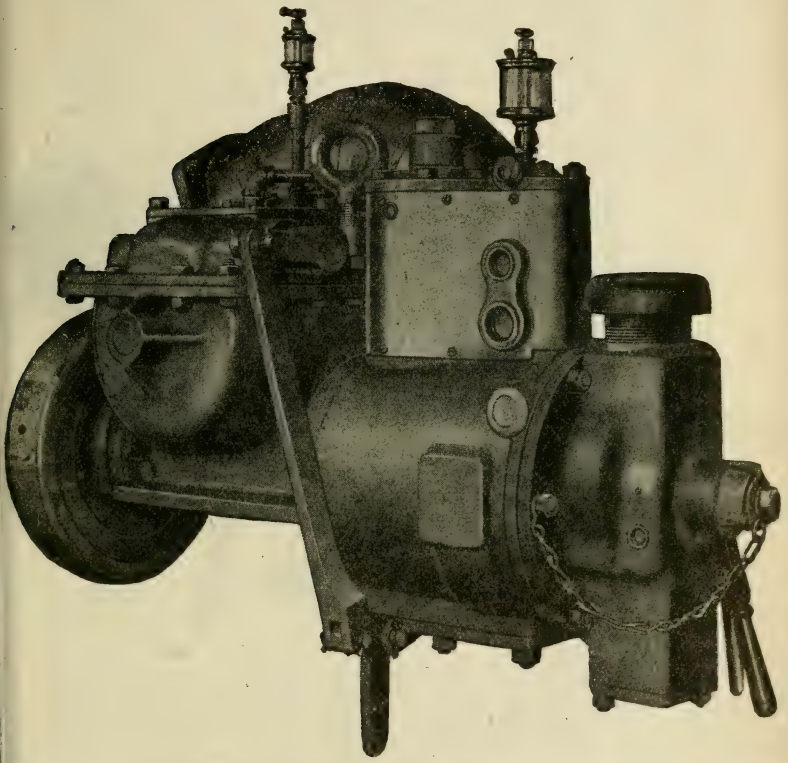

Fig. 5—Back View of 4x3½ Variable-Speed Elevator Engine and Sprocket Wheel Casing, Showing Friction Clutch Housing and Operating Lever

maintained by direct feed from oil cups on crank case and friction clutch housing as shown in Figs. 5 and 6.

The valve is of the piston type. The valve and piston

rings are made of special mixture packing ring metal. The main bearings are supplied with special bearing bronze solid bushings pressed in.

The cylinder head is fitted with a relief valve which prevents breakage of parts if water should reach cylinder.

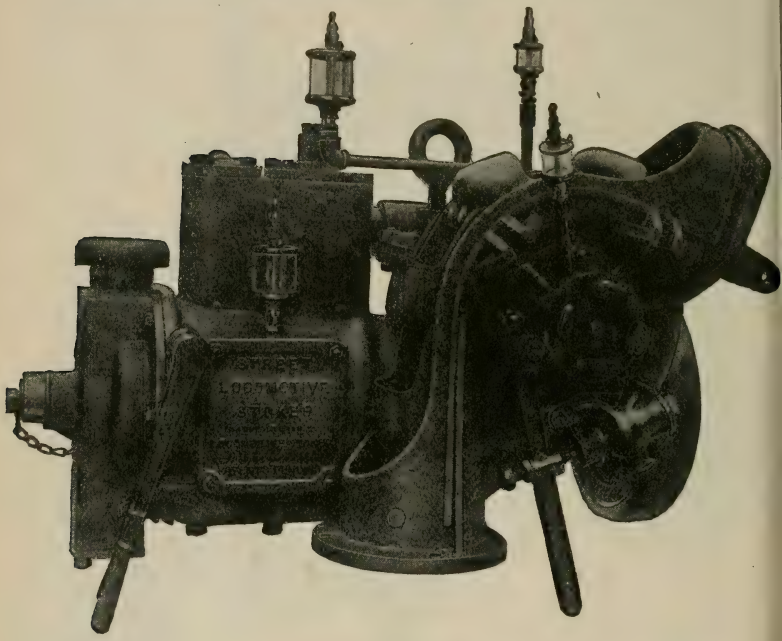

Fig. 6—Front View of Elevator Engine and Sprocket Wheel Casing, Showing Controller, Controller Cam and Elevator Buckets

The outer main bearing is provided with an oil separator which allows surplus water leaking by piston and valve to pass out through separator overflow and retains the oil in crank case at proper level.

The oil from worm gear lubricator, after flowing over the worm wheel and worm, passes through an opening into crank

case of engine and maintains proper oil level for lubricating engine.

A suitable starting ratchet is provided for starting engine and for backing up engine if desired — the starting ratchet being both right and left hand as shown in Fig. 7.

A drilled mark is also placed on engine fly-wheel. When this spot is in middle of front of fly-wheel, engine will start by turning steam on.

Variable-Speed Engine Governor.—The speed of the 4 x 3½ elevator engine is controlled by a shaft governor of variable

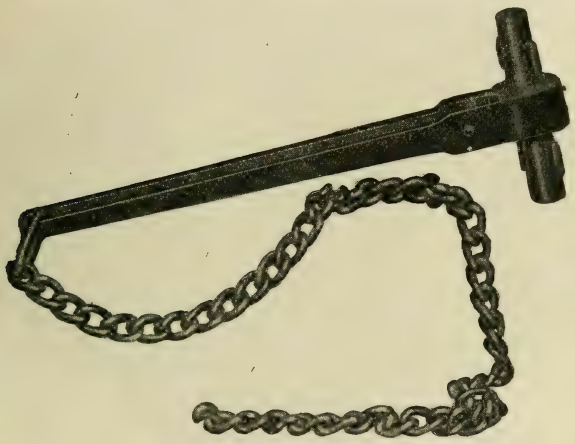

Fig. 7—View of Starting Ratchet

cut-off type having an outside adjusting lever for changing the tension of governor springs while engine is running, thus making it possible to change engine speed as may be desired while stoker is in operation.

The governor adjustment compensates automatically for the different pull of governor weights at the different speeds, thus securing uniform and stable engine control when load on engine changes at any given speed.

The engine will, therefore, always operate at the proper speed for each notch on outside control lever quadrant.

The operation of the governor at any of the different speeds may be described as follows:

When the load on the engine is decreased the speed momentarily increases, causing an increase in the centrifugal force of the governor weights. This increase in force overcomes the restraining force of the governor weight springs, allowing the governor weights to move outward. The outward move-

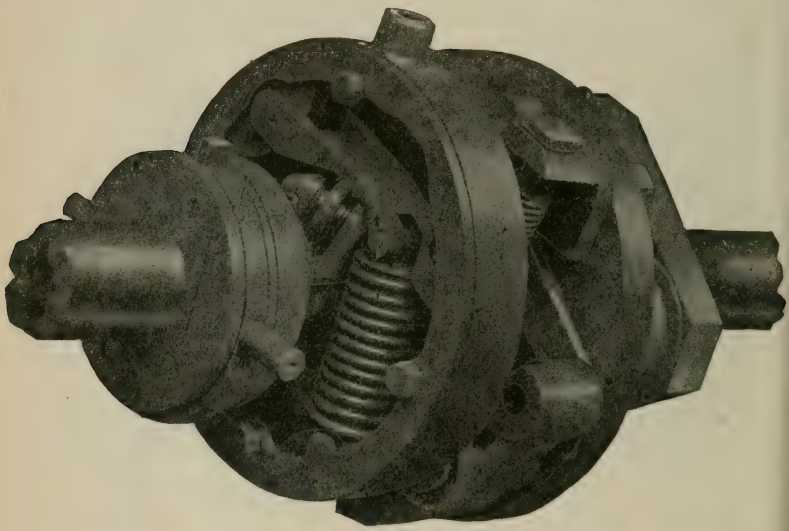

Fig. 8—General View of Variable-Speed Governor, Showing Auxiliary Spring, Yoke, Connection for Outside Lever and Adjustable Fulcrum Lever

ment of the weights causes the eccentric to swing so that its center approaches the center of the engine shaft. This in turn shortens the valve travel, causing it to cut off sooner and consequently admits less steam each stroke to the engine cylinder; and this smaller supply of steam causes the engine to slow down to its former speed.

An increase of load will momentarily decrease the engine speed and thus decrease the centrifugal force of the governor

weights. The governor springs will then overcome this decreased pull of the weights and move in toward the shaft. This movement carries the eccentric center farther from the center of shaft and increases the valve travel, admitting more

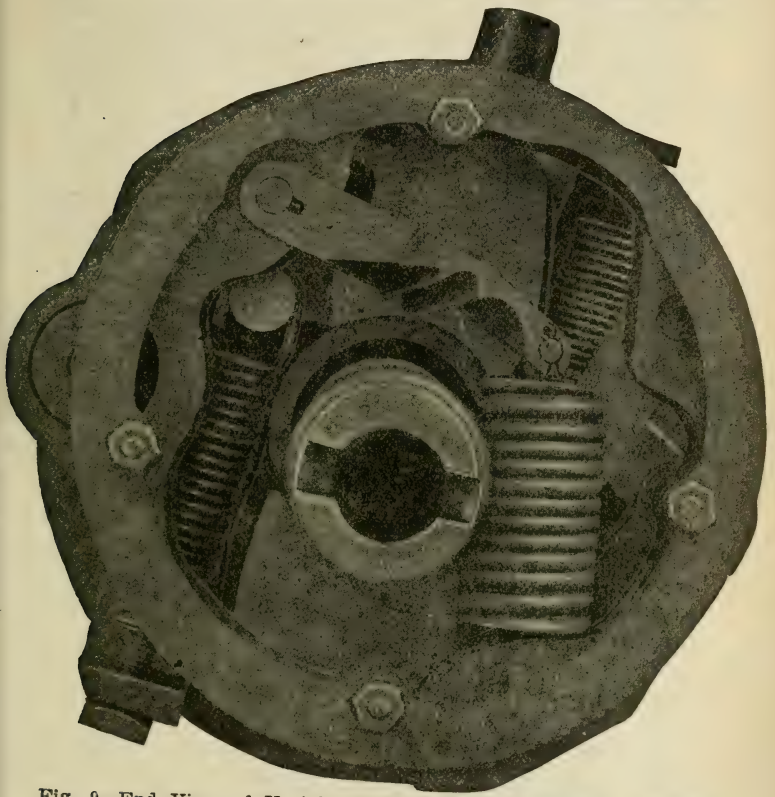

Fig. 9—End View of Variable-Speed Governor, Showing Inclined Track in Adjustable Fulcrum Lever, Auxiliary and Main Governor Springs

steam to the cylinder each stroke of the engine. This will increase the power of the engine and cause it to return to its former speed.

From this it can be seen that the centrifugal force of the governor weights acting against the restraining force of the spring regulates the amount of steam admitted to the cylinder and thus keeps the engine at a constant speed at any notch on control lever quadrant, regardless of the load.

From the foregoing it can be seen that increasing the tension of the governor weight springs will increase the speed of the engine, while a slacking up of the spring tension will slow down the engine.

The control lever yoke pushes the fulcrum roller up the inclined track shown in Fig. 9, thus increasing pull of lever at point of attachment to auxiliary spring, thereby increasing the governor spring tension in proportion to movement of outside lever.

The track being oblique across the lever, as well as inclined, makes the lever longer for the high speed, thus compensating for increased pull of weights.

The main and auxiliary governor springs have arrangements also for manual adjustment.

Changing tension of main governor springs (the two smaller ones) has no more effect upon the slower speeds; and changing tension of auxiliary spring (the large single spring) has more effect upon the high speeds, but adjusting either effects the speed through all the range of control.

In case it is impossible to obtain a correct speed of the engine by changing the tension of the springs, it will probably be found that the parts of the governor bind and do not allow the members to move freely, or that governor has become badly worn, allowing the governor weights to rub on the side of the eccentric or against the short links, thus interfering with the proper travel of the valve.

The breakage of one of the governor weight springs will also effect the speed of the engine, causing it to run at about half the correct speed.

The governor is entirely enclosed and oiled by the splash mixture of oil and water in crank case. This makes it important that constant supply of oil be given the crank case. It is also important that valve and piston rings be kept tight to prevent the escape of steam into the crank case, which would

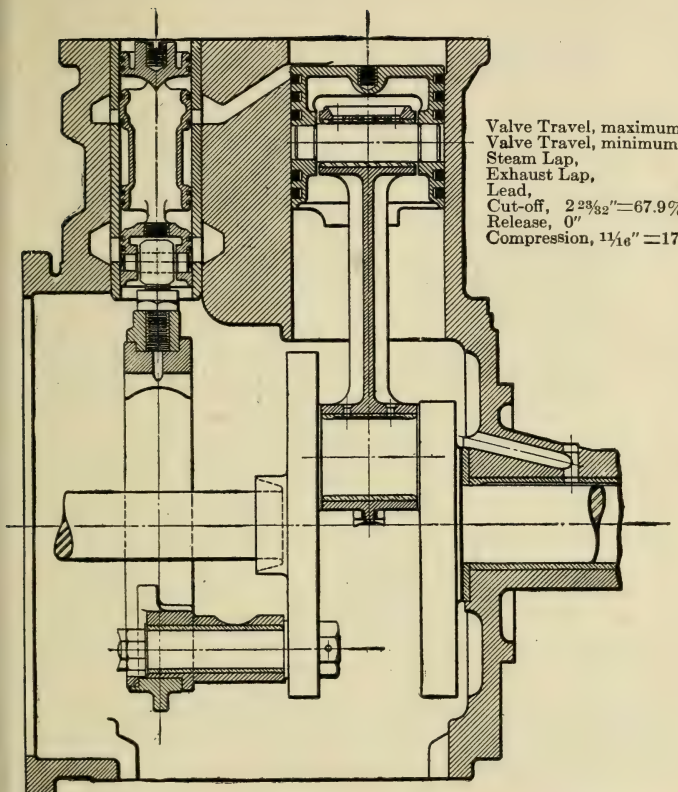

Fig. 10—Cross-Section View of Cylinder and Valve Chambers of 4x3½ Variable-Speed Elevator Engine to aid in properly setting valve by using steam. This drawing shows valve at "line in line" position and valve bush properly inserted

wash out all the oil. A failure to set the main lubricator feed to the steam line will often result in a broken governor, as the excessive friction in the valve bush will cause the governor weights to pound.

INSTRUCTIONS FOR SETTING PISTON VALVE OF 4 x 3½ VARIABLE-SPEED ELEVATOR ENGINE

To Set Valve by Using Steam.—Remove cylinder head and valve chest head and also loosen lock nuts on eccentric rod. Turn engine over so that piston stops at its highest position. Open valve in steam line to engine very slightly. Turn valve and find a position for it by trial so that it opens the inlet port just as the piston starts downward from its highest position. This will be indicated by steam beginning to blow. This sets the valve "line in line," commonly called "setting the valve with zero lead."

The very best operating results will be secured by setting valve at "line in line" position, or at not to exceed one-half (½) a turn above this position, but in no case below it.

Care should be taken in all cases to see that the top of valve bushing is exactly flush with top of cylinder as shown in Fig. 10.

To Set Valve by Using Dimensions.—Remove cylinder head and valve chest head and also loosen lock nuts on eccentric rod. Turn engine over so valve is at its highest position as shown in diagram, Fig. 11. Screw valve down until top of valve is $\frac{3}{16}$" above top of cylinder as shown in Fig. 11. This also sets valve at "line in line" position, or with zero lead.

The best operating results will be secured by setting valve in this way, or at not to exceed one-half (½) a turn above this position, but in no case below it.

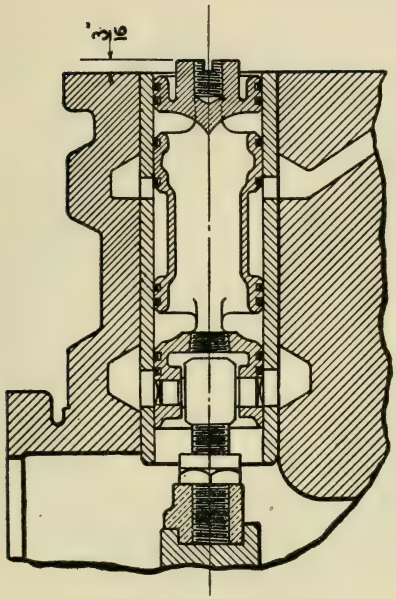

Fig. 11—Diagram, Showing Position of Piston Valve, when Setting by Using 3/16-inch Dimension from Top of Cylinder

Care should be taken in all cases to see that the top of valve bushing is exactly flush with top of cylinder as shown in Fig. 11.

Before tightening lock nuts on valve stem, care should

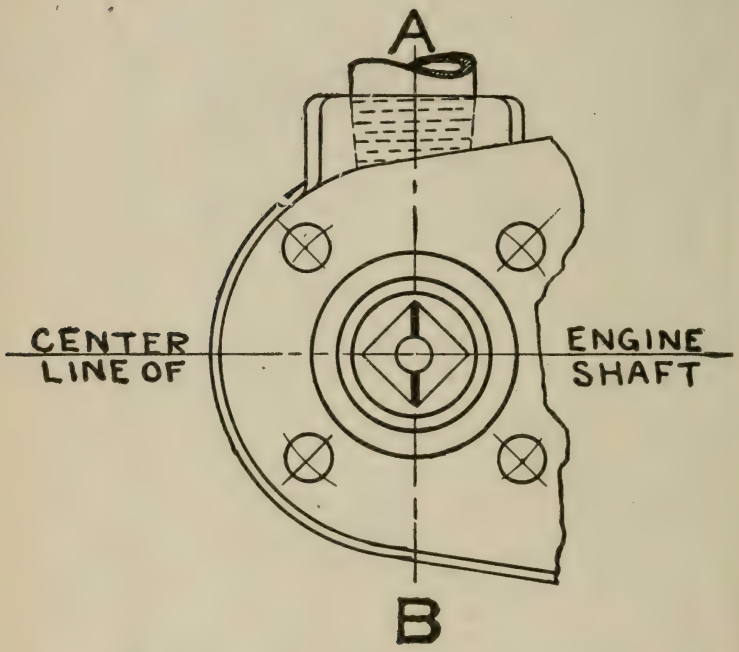

Fig. 12—Top View of Valve, Showing Cut in End of Valve Body at Right Angles to Center Line of Engine Shaft

be taken to see that valve wrist pin is in line with engine shaft. This will be indicated by the heavy cut in top of valve body being at right angles to center line of engine shaft as shown running in direction between A and B in top view of valve, Fig. 12.

Worm Gear Transmission Sprocket Wheel Casing Friction Clutch.—The power supplied by the 4 x 3½ Variable-speed Elevator Engine is transmitted to the stoker through a special design of worm gear drive, 20-1 ratio, carried by the sprocket wheel casing.

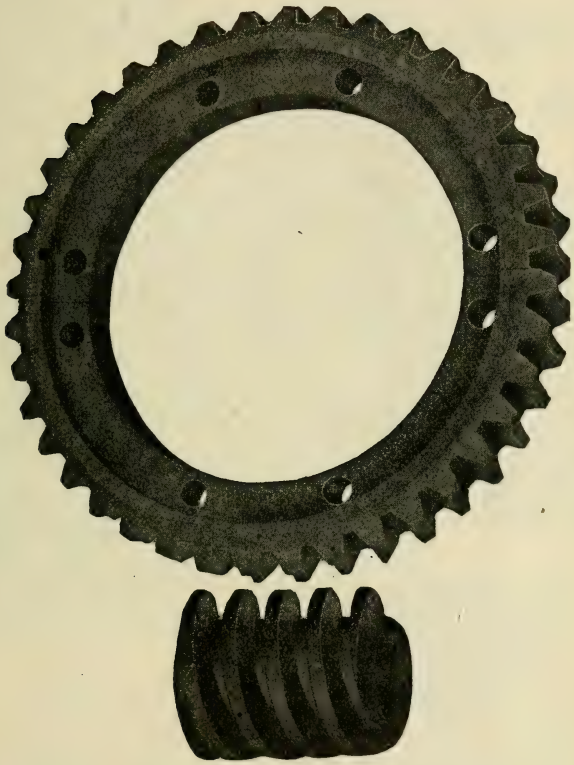

Fig. 13—Worm Wheel Rim and Worm

The worm wheel is carried by the friction clutch drum and is made in halves for convenience of assembly as shown in Fig. 13.

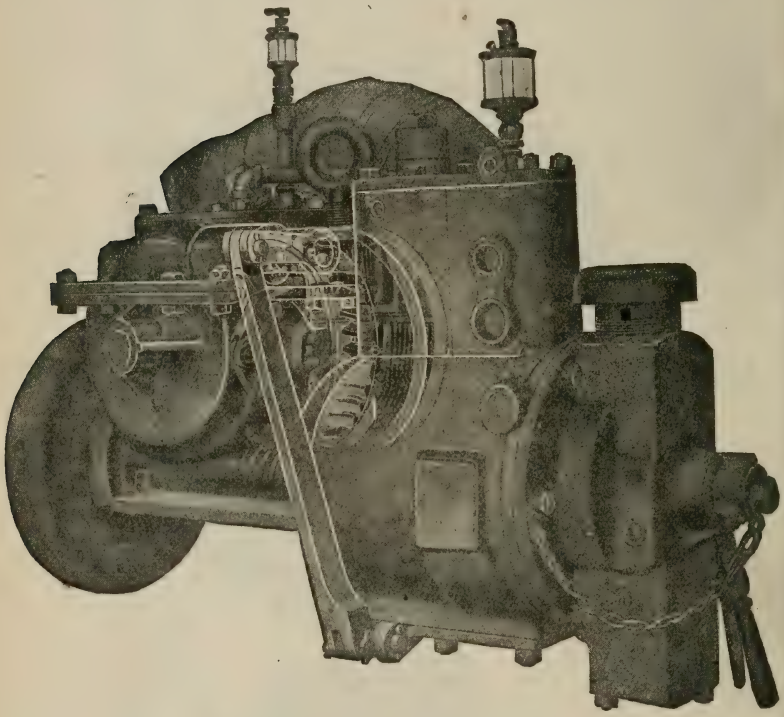

Fig. 14—Phantom View of Engine, Showing Clutch

The sprocket wheel casing also carries the friction clutch as shown in back view of Elevator Engine, Fig. 5.

This clutch is simple in form, being of the plate type as shown in Figs. 14, 15, 16 and 17.

The plates are alternately brass and steel, running in oil applied to top of clutch by spiral on clutch drum as shown in Fig. 16.

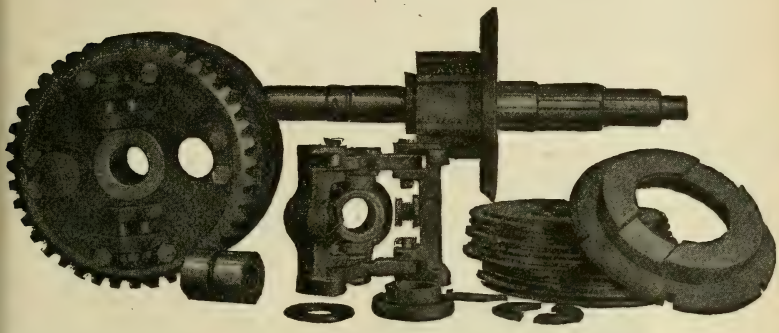

Fig. 15—View of Dismantled Clutch

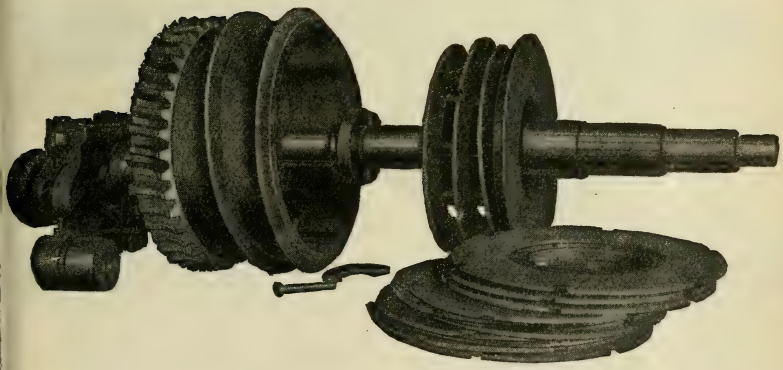

Fig. 16—View of Dismantled Clutch, Showing Spiral Oil Carrier

The clutch compression members are operated through means of a lever placed within easy reach of fireman.

This friction clutch is interposed between the elevator engine and stoker for the convenience of fireman in starting

and stopping supply of coal to fire-box. When stoker is stopped by throwing clutch out of operation, the elevator buckets remain filled; and, when again started by throwing in clutch, the next bucket to register at discharge pipe opening will deliver coal immediately to the distributers.

This prompt starting and stopping of coal delivery to fire-box through the use of the clutch, together with the flexible control of speed of stoker with the variable-speed engine governor, makes it possible to keep a uniform fire-box temperature with the maximum of economy.

The worm drive and friction clutch run in oil supplied by special sight-feed oil cup attached to top of clutch housing as

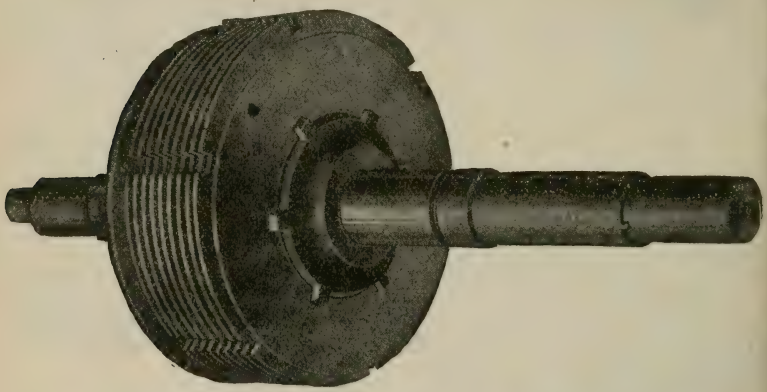

Fig. 17—View of Friction Discs Assembled on Sprocket Shaft Drum

shown in Fig. 5. This oil, after lubricating worm drive and clutch, flows into engine crank case to assist in maintaining oil film on water level for main lubrication of elevator engine.

The front of sprocket wheel casing is supplied with removable flange for giving ready access to keys in cross shaft. A removable top casing is also provided for inspection and oiling of elevator chain.

The main driving sprocket is of cast steel with special design of teeth for the elevator chain buckets, to permit nor-

mal wear without climbing. The elevator engine can be removed from sprocket wheel casing by removing the fly-wheel and taking nuts off studs at connection between engine and casing. This makes a very convenient arrangement for repairs to elevator engine.

Screw Conveyor.—The conveyor consists of a wrought steel trough in which is a heavy steel helicoid screw and over which is placed a bar screen of special design as shown in Fig. 22.

Fig. 18—General View of Complete Conveyor

The screw conveyor is made of suitable length for shovel plate of each locomotive tender; and, for installation on new tenders built for stoker firing, it is customary to use a longer conveyor and run the shovel plate well back in tank. In some cases the conveyor troughs have been ten feet long.

Fig. 19—View of Screw Conveyor Trough

The trough is flexibly attached to back casting of elevator hopper on locomotive by a heavy pivot pin in bottom of end V casting on front of trough, and is supported on tender floor underneath shovel plate by resting in a malleable slide support casting.

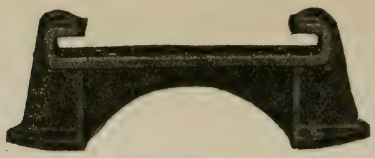

Fig. 20—View of Slide Supporting Casting

A slide plate on bottom of trough is provided for wearing surface and to give proper movement to meet the flexibility between engine and tender.

The trough, screw and screen move with the engine, merely resting in slide casting on tender, and all three can be readily uncoupled from engine and left with tender by drawing the pins at pivotal point.

Fig. 21—View of Helicoid Screw

The heavy wrought steel helicoid screw is carried at back by a suitable bearing in end casting of trough and at front end has universal joint connection to driving shaft in elevator hopper. The pin can be drawn from universal joint yoke when it is desired to disconnect conveyor from engine.

The conveyor screw is driven by special design of link belt and sprockets on front of elevator hopper as shown in Fig. 26.

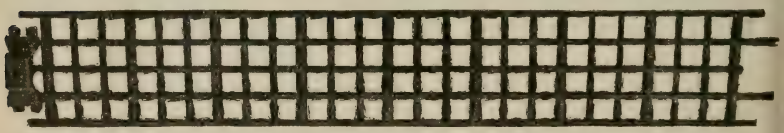

Fig. 22—View of Screen for Locomotive Tender Screw Conveyor

The screen over conveyor is of rectangular wrought steel bars, spaced by round wrought steel bars to two and one-half

inch square openings. All coal must pass through these openings before being handled by stoker. This size and design of screen is for handling what is termed "nut run" coal—that is, a mixture of nut, pea and slack in about equal proportion. The

Fig. 23—View of Screen Shaker Rod

screen is carried on slides under shovel plate and is kept in motion, when stoker is running, by means of a screen shaker rod attached by pivot pin connection to bell crank on elevator hopper. The bell crank is operated by an eccentric on lower left hand sprocket wheel shaft in elevator hopper.

The movement of the screen assists in ready passage of coal to screw conveyor below.

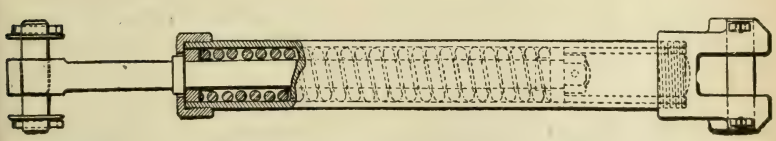

Fig. 24—Cross-Section View of Screen Shaker Rod, Showing Interior Spring Arrangement

The screen shaker rod connection between screen and bell crank is provided with a substantial steel spring inside of barrel.

The purpose of this spring is to provide for the regular movement of bell crank in the event of screen becoming clogged by mine spikes, pieces of wood or other material which might catch between end mesh of screen and slide plate.

The *Elevator* consists of a hopper, made of heavy steel plates and angles, for receiving the coal delivered by the screw conveyor and a chain of elevator buckets.

Fig. 25, shows the opening at end of conveyor trough, also location of screen shaker, bell crank, universal joint drive for helicoid screw and idler pulley for keeping elevator bucket chain below screw shaft.

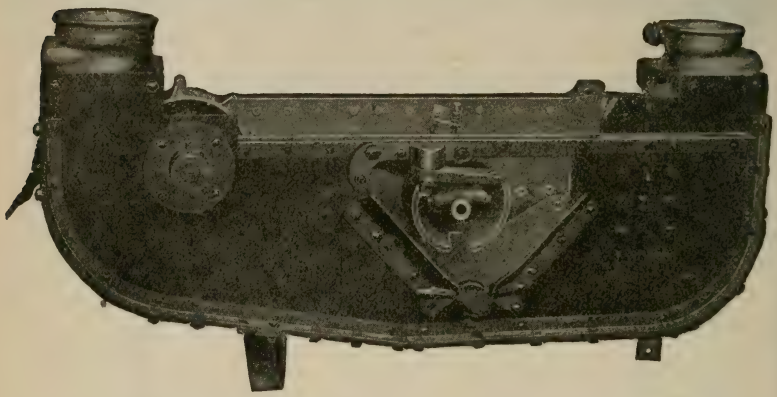

Fig. 25—Elevator Hopper. Back View, Showing Conveyor Trough Opening

Fig. 26 shows link belt drive on front of elevator hopper for helicoid screw and arrangements for taking up slack in both link belt and main elevator bucket chains. The right hand main lower sprocket idler has an up and down adjustment of about seven inches for taking up slack in main elevator bucket chain.

The elevator buckets do not drag on bottom of hopper, as the elevator bucket chain is kept tight enough to allow buckets to fall only within about an inch of the hopper bottom. This insures buckets filling properly by always running through a body of coal.

Suitable oiling places will be found at bearing points of moving parts on hopper, all of which are easily accessible through trap door in locomotive cab floor—the hopper being

Fig. 26—Front View of Elevator Hopper, Showing Screw Driving Sprockets, Link Belt and Tighteners for Link Belt and Elevator Chain

located between floor of cab and deck plate and firmly secured to the frames.

Doors or slides are provided at each end of hopper for cleaning and inspection purposes.

The coal is taken out of the elevator hopper and carried to the discharge pipe by means of a main elevator chain of specially designed elevator buckets. Each bucket is made of solid one-piece malleable casting, and is supplied with hardened steel bushings through hinge bearing. The hinge pins are

Fig. 27—Suction of Elevator Bucket Chain

made of three-quarter inch special steel, and are hardened to correspond with the hardened bushings used in bottom hole of the elevator buckets. The pins are fastened rigidly into the bosses or ears of buckets and work freely in the long bushed

bearing. This design insures great strength and minimum wear. The chain has a total strength of over 25,000 pounds, and the large hinge pins insure long life without breakage.

The chain of buckets runs at about one hundred feet per minute and will elevate approximately twelve thousand pounds of coal per hour when running with the buckets full. The usual operation is with buckets about half full.

The buckets are designed to fill and empty properly at maximum speed.

The chain is not driven by the pins, but by the driving sprocket teeth engaging the heavy boss on bottom of bucket which also insures long life.

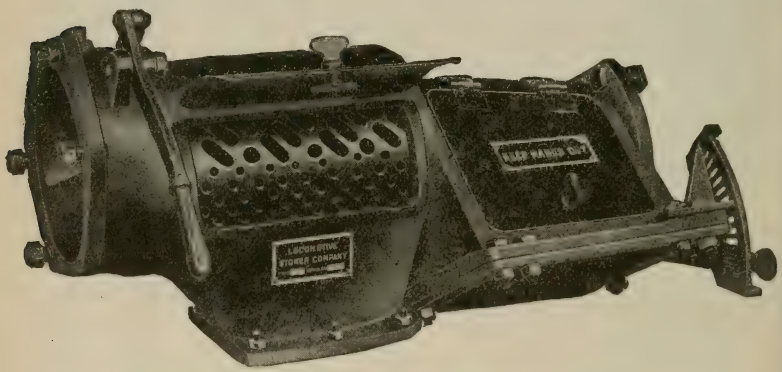

Fig. 28—General View of Discharge Pipe, Showing Adjustable Screen and End Lever and Quadrant for Dividing Vane

Discharge Pipe or Distribution Center.—The discharge pipe is located in the central upper portion of the elevator casing, and embodies mechanism for dividing the coal between three distributers. The left hand end carries a circular screen made of sheet metal and is provided with four sets of perforations of different sizes.

The coal, after entering the discharge pipe, is dragged by the elevator over this screen, and the smaller particles pass through it and into the center distributer. Any particles too large to go through the screen pass over it, and are divided between the right and left hand distributers.

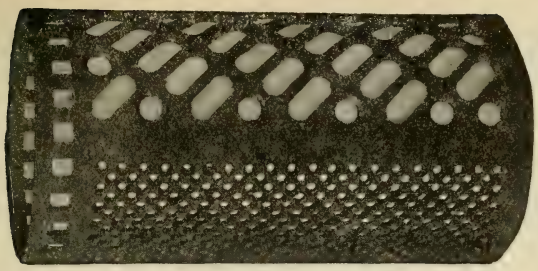

Fig. 29—Discharge Pipe Screen

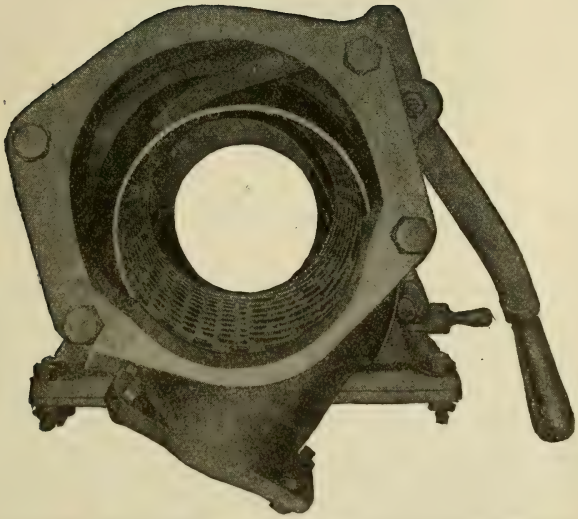

Fig. 30—Left Hand End View of Discharge Pipe, Showing Screen and Ratchet Lever Used for Revolving It

The quantity of coal going into the center distributer is varied by changing the size of the openings brought into use in the screen. With small openings down, a small quantity of coal goes through the center distributer. If a larger amount is wanted at this point, a larger set of holes is brought down. A ratchet lever, hand operated, is provided as a means by which the fireman can bring the desired set of holes into use. A door is provided in the discharge pipe directly over the screen to give means for observing the position of the holes.

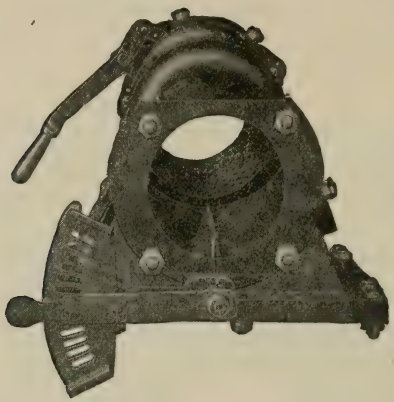

Fig. 31—Right Hand End View of Discharge Pipe, Showing Dividing Vane with Lever and Quadrant for Operating It

The discharge pipe carries a dividing rib, lever and quadrant which furnish a means for varying the proportion of the coal going to the right and left hand distributers. Throwing the lever up increases quantity of coal passing to the left hand distributer, while pulling it down increases the quantity passing to the right hand distributer—thus furnishing a means for keeping the fire even across the firebox. It will be noted that this discharge regulator is designed and located so that the rolling of the locomotive as it passes around curves or over uneven track has no effect on the distribution, regardless of whether the locomotive is on a level track.

The controller is a small steam valve of very simple construction and carries a lever pivoted thereto, having on its upper end a roller for engaging projection on the controller cam. On the lower end of this lever there is a handle for opening this valve by hand. The valve body is made of brass, with brass fittings, the lever of malleable iron, the valve seat and stem of steel, and all of the parts are made as rugged as it is possible to make them.

The controller lever which carries the roller, as shown in Fig. 32, also carries the adjusting screw or engaging boss

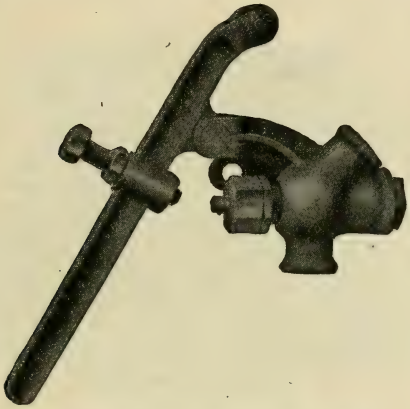

Fig. 32—Controller Valve and Lever

which compresses the valve stem and opens the valve intermittently at regular or irregular intervals, depending upon the number of cams turned out for use on the controller cam head.

The controller cam head is in the form of a disc about five and one-half inches in diameter mounted on the end of the sprocket wheel shaft and revolves at a constant speed of about thirty revolutions per minute. It has four projections which can be thrown in or out by the fireman, and when thrown out they come in contact with the end of the controller lever and open the controller valve intermittently, admitting

steam to the distributers. There are projections of eight different sizes, which give the fireman the option of using jets of eight graduated durations of time and having one, two, three or four jets per revolution of the cam. The distance to which the coal is projected into the firebox is governed by the number or the duration of the steam jets. A jet of long duration will throw the coal further than a short one. If coal is wanted on the front end of the firebox, jets of long duration, or several in number, are used. If coal is wanted at the back end of the firebox, a small number of jets of short dura-

Fig. 33—Controller Cam Head Which Carries the Adjustable Cams

tion are used. For ordinary firing it is customary to use one small, one medium and one large cam, which gives one short blast, one medium and one long blast for each revolution of the cam head.

The size and form of the handles on the cams will indicate to the fireman which to use, as each cam handle is made of similar size and form to its cam.

Distribution or Spreading System.—The starting of the coal towards the three zones or areas in the firebox is done by the devices in the discharge pipe at the distribution center, as

previously explained, but the actual spreading of the coal over the three overlapping zones or areas is accomplished through the means of the three firing points at the three stoker openings through the back-head of locomotive boiler. The fire door is left undisturbed so that it can be used for hand firing at roundhouse and on sidings, or when drifting.

Three elbows, containing the firing nozzles, are placed at the three stoker openings and serve as firing plates. The coal is stopped momentarily in the elbows by the special design of retarding rib and is then blown through the *Distributer Tubes* on to the under side of the *Distributers* by the jets of steam admitted to the firing nozzles in the elbows by intermittent action of controller valve.

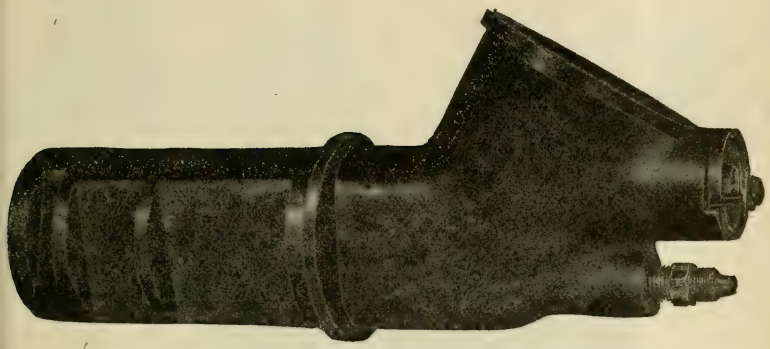

Fig. 34—Center Distributer Elbow and Tube Combined

The center elbow is made with distributer tube attached, as shown in Fig. 34.

The elbows are provided with peep hole, with swinging cover, through which the firing can be observed. The center distributer elbow is the firing point for the fine coal.

The right and left side elbows are arranged for use of removable distributer tubes, as shown in Fig. 36.

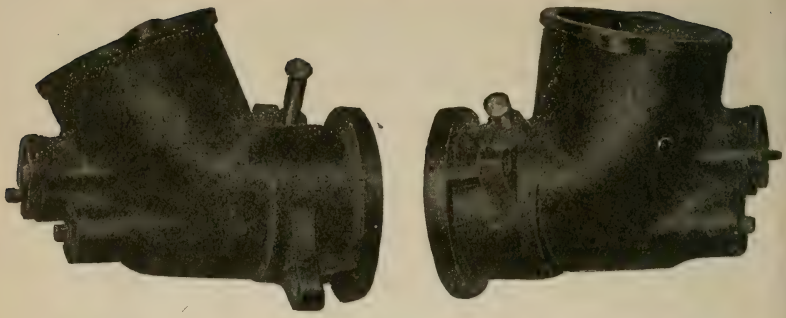

Fig. 35—Right and Left Hand Distributer Elbows

The side elbows are the firing points for the coarse coal and are also provided with peep hole through which fireman can observe quantity of coal being fired to each side of fire-box and regulate the dividing vane accordingly.

The distributer tubes for side distributer are removable, as shown in Fig. 36.

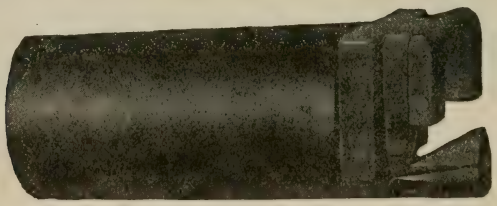

Fig. 36—Distributer Tube. Right and Left Hand Distributer Tubes are Alike

These tubes serve as the connection between the firing elbows and the distributers, the latter being carried on fire-box end by the set of lugs shown. Since there are no bolts to be removed or joints to be made, the distributer castings simply slide into place and can, therefore, readily be lifted off and replaced when necessary.

Fig. 37—Bottom View of Center Distributers

Fig. 38—Bottom View of Center Distributers

Fig. 39—Bottom View of Center Distributers

Several different forms of center distributer castings are used as shown in Figs. 37, 38 and 39. The style used on any given locomotive depends upon length in relation to width of firebox and kind of coal regularly supplied.

Fig. 40—Bottom View of Right and Left Hand Side Distribution Castings, Showing Deflecting Ribs Which Place Part of the Coal in Back Corners of Firebox

The right and left hand side distributer castings are generally of the form shown in Fig. 40. They are made of either plain cast iron, cast steel or cast iron with a refractory housing.

These side distributer castings deflect the coarser coal in a general forward direction over a fan-shaped area at the sides of firebox; these areas overlap at center and thus secure an even scattering of the coarser coal over the entire grate area. The center distributer covers with fine coal the back central part of the grate, the three zones or areas overlapping as explained.

The center and side distributer castings hang upon the firebox end of the distributer tubes, substantial and loose fitting lugs being provided for supporting them; and, as no bolts are used—gravity alone holding them in place—it is but a moment's work to replace them when necessary.

General Instructions Oiling.—All stokers should be oiled before leaving terminal. The points of oiling are as follows:

1. Fill sight feed oil cups on Elevator Engine with *valve oil*, adjusted to feed 2 drops per minute (snap in vertical position, *open;* in horizontal position, *closed*).
2. Sprocket wheel shaft, front and back, *valve oil.*
3. Hopper sheaves or idlers, *car oil.*
4. Screen shaker and eccentric strap, *car oil.*
5. Universal joint and bearing, *car oil.*
6. End bearing on screw conveyor, *car oil or grease.*
7. Stoker feed on main lubricator, set to feed about 2 drops per minute.

To Start and Operate Stoker.—Open engine cylinder cock full, then open throttle valve about two turns of wheel and turn fly-wheel by hand, or use starting lever. After engine has made a few revolutions, open throttle wide, and close cylinder cock tight. After stoker engine has been running for a few minutes, open cylinder cock intermittently to relieve any back pressure, thereby preventing engine knocking and ultimately breaking a governor spring or weight.

Particular attention must be given stoker engine when *too much water is carried in boiler.* In such cases, cylinder cock must be left open until water in boiler returns to its normal level, otherwise engine will stop, or a broken governor will be the result. Stoker engine will *not* work water through cylinder.

After stoker engine has been started, see that two or three controller cams are turned out. Be sure the distributer pipes are free from coal, and that controller valve works properly.

Place variable-speed governor control lever in, or near, middle position and pull clutch into operation. This will start entire stoker running.

Open first coal slide over screw conveyor, and see that coal starts through screen.

The coal will then be conveyed, elevated, screened and distributed over the entire firebox area.

Coal Distribution in Firebox.—The distribution of coal is regulated by three separate attachments as follows:

1. Controller Cam.
2. Screen, large and small holes (in discharge pipe).
3. Dividing Lever (lever on quadrant at end of discharge pipe).

The *Controller Cam* has four cams of different lengths; under normal operation two are out, and never more than three, unless some unusual condition exists. When enough coal cannot be supplied to the flues, then use four.

The larger and greater number of cams in use, the heavier the stoker will feed to the flues. The smaller and lesser number of cams in use, the heavier the stoker will feed at the door. The fireman can easily adjust this by watching his fire for the first few miles out of a terminal, while engine is working.

The *Discharge Pipe Screen* puts the fine coal through the center distributer, which in turn puts it on the back grates at the door. If the fire is too light at the door, revolve the screen to the next larger holes. If the fire is too heavy at the door, revolve the screen to the next smaller holes, and so on.

Dividing Lever. If the fire is too light on right side of grates, move dividing lever down. If too light on left side, move dividing lever up. Do not move this lever *more than one hole* at a time, from central position, otherwise a bank will form quickly.

Governor Lever. The rate of coal delivery can be controlled by the use of variable-speed governor lever in its different positions to increase or decrease speed of entire stoker mechanism.

Friction Clutch. The operating lever for instantly starting or stopping the coal supply is within easy reach.

General Suggestions.—Before leaving terminal, see that fire is clean and in good condition; build up a good level fire with shovel, after starting stoker as hereinbefore explained, open one or more slides in tank and make sure coal is getting to

screw conveyor. However, *care must be taken not to allow too much coal to go through the screen, as it will pile in the trough and will be wasted over the sides.*

If screened run of mine coal is used, the slides should not be opened more than 4" to 6"—this to be left to the discretion of the fireman.

Do not use hook or rake unless absolutely necessary; however, it is a good plan to feel the fire when first starting out to see just what condition it is in. By doing this, the proper adjustment can be made in the distribution.

Do not feed iron, rock, slate or waste through the conveyor.

When train is standing on siding for a short period, shut stoker off by throwing friction clutch out of engagement. When train is to stand for a longer time, the stoker engine should be shut off, cylinder cock opened, main lubricator connection closed and sight-feed oiler snap levers turned down.

The locomotive should be hand fired when not working steam.

Distributer Clogs.—Hold open the controller valve hand lever, and poke out coal in the elbows with small bar or broom handle. If necessary, open distributer pipe door.

If sufficient coal cannot be supplied front grates: 1. Put in more controller cams.

2. See that controller valve throttle opens wide.

3. See if the controller valve lever is bent, giving a small controller valve opening.

4. See that the steam jets are blowing freely, and are not plugged with pipe scale.

5. See if the distributers are warped out of shape and point too low. If such is the case, report it to the roundhouse foreman.

Duties of Firemen on Arrival at Terminal.—Before leaving a stoker engine at fire track, fireman should close the slides in tank and let elevator engine run long enough to remove *all coal* from the conveyor and hopper, open cylinder cock and close stoker throttle valve tight. This will eliminate any possibility of the stoker freezing in extremely cold weather.

Roundhouse Inspection.—It should be the duty of the Stoker Inspector in the roundhouse or at the fire track, to start up the stoker engine and note the general condition of the machine, paying particular attention to the following:

See that conveyor trough, hopper and distributer pipes are free from coal.

See that the distributers are not burned off, or are not too low; if burned off, renew them; if too low, raise them.

See that the steam jets are blowing freely. If not, remove pipe plug in elbow, and run $\frac{1}{16}$" wire through hole in center.

Note the speed on elevator engine, which should be 400 r. p. m. at fly-wheel when governor control lever is in first position and 600 r. p. m. in last notch. To determine engine speed: start elevator engine, throw out one controller cam and count the revolutions. The number of revolutions thus obtained during one minute multiplied by 20 will give the engine speed. For example:

20 r. p. m. Cam $\times$ 20 = 400 r. p. m. Engine—1st notch.

30 r. p. m. Cam $\times$ 20 = 600 r. p. m. Engine—7th notch.

The speed of the elevator engine must not exceed the above limitations.

The above speeds are obtained by adjusting the governor springs on governor inside of crank case as explained.

If a governor spring is weak, and requires over $\frac{3}{8}$" tension to get the required speed, *renew it at once.*

Do not let an engine go out with a *knock* in crank case (governor box). It is a sure indication of an improperly adjusted governor, or a burned or worn connecting rod bush. A few minutes' work at terminal will save considerable delay, should this adjustment have to be made on road.

See that the screw, screen and shaker are working properly.

Inspect elevator chain carefully, taking up slack when necessary.

Be sure that idler in guide is tight on right side.

Inspect link belt chain on front of hopper.

Taking Coal.—Close the tank opening with the slide cover plates before coaling the tender.

POSSIBLE TROUBLES

If Coal Stops Feeding:

1. See if the screen in tank is covered over with lumps.

2. See if the elevator engine has stopped.

If the Elevator Engine Stops:

1. Close the throttle, open the cylinder cock and throw clutch out.

2. Turn the engine backwards by hand, or with the starting lever, and then try to start again.

3. If unable to start, see if the lower hopper is filled with coal. To clean out coal, open small door on left side of hopper.

4. See that the elevator is not clogged with a piece of wood or stone.

5. Remove sprocket wheel casing cover to see if there is any foreign substance wedged in the sprocket wheel teeth.

6. After the elevator engine is working freely, place governor lever in one of the higher speed positions; and, if engine continues to run but elevator does not start, this will indicate that clutch compression spring needs tightening. If elevator engine stops when clutch is thrown in, it is an indication of a clog in elevator or conveyor.

7. Report trouble to Roundhouse Foreman on arriving at terminals.

DON'TS

1. *Don't leave the tank openings uncovered when coaling the tender.*

2. Don't try to pound lumps of frozen coal through the screen.

3. Don't allow the starting lever to remain in the end of the elevator engine shaft.

4. *Never let go of the starting lever when starting the elevator engine.*

5. Don't let coal stand in the conveyor trough between trips.

6. Don't allow coal to accumulate in the tank cut-out and become packed around the outside of the conveyor trough. This will break the trough when the locomotive is rounding a curve.

7. Don't allow banks to form in fire under the side distributers, as this will burn them off.

8. Don't oil sheaves and screen shaker in lower hopper while elevator is running, as it is dangerous. Do this before starting the engine.

9. Don't run the stoker without distributers. The distributers are designed to spread and SAVE coal. Leaving them off means unnecesary WASTE of coal.

CRAWFORD DOUBLE UNDERFEED STOKER

This mechanical stoker has been applied to a large number of locomotives on the Pennsylvania Lines after a most complete test and the most careful attention to details. It is the first "underfeed" stoker successfully applied in this country.

The large inserted cut shows a cross section of this stoker applied to the engine and tender of a modern locomotive, all the parts being numbered and listed below in their proper names.

In brief, the stoker operates as follows:

The engine (1) has a reciprocating motion to crank arm (3) which is connected to shaft (4); this gives a reciprocating motion to crank arm (5), the top of crank arm (5) having a complete travel of about 16 inches. To crank arm (5) is attached two connecting arms (6) which are connected to plunger cross bar (7). To the back of plunger cross bar (7) are connected two arms (35) known as the long driving rods for the conveyor mechanism; these long driving rods connect direct to each end of crusher single-tree (36) and give a reciprocation motion to the crusher (37). Also, connected to the long driving rods (35) are the connecting rods (51) which connect to the two rocker arms (52); these rocker arms being pivoted on the fulcrum brackets (53). The top of the rocker arms are connected through two short connecting links to each end of the conveyor single-tree (56). This conveyor single-tree, therefore, imparts a reciprocating motion to the paddle carrier (43); this paddle carrier is in effect a ladder with rungs formed by the paddle rods (44), and the paddles (46) are about 2 inches wide, seven of them being connected to each of the paddle rods. The conveyor trough (41) remains stationary.

As crusher (37) moves in a forward position the coal drops into the crusher through the hopper hole in the bottom of the

tank. As the crusher returns to its back position any coal projected above the crusher (37) is sheared off the edge of crusher hopper (39). As the crusher proceeds past the end of the coal cut-off slide (66) a portion of the coal is dropped into the conveyor hopper (42); the amount of this coal being dependent upon the position of the coal cut-off slide (66) which is operated by the coal cut-off operating handle (62) through a series of rods. On the back motion of the conveyor ladder and conveyor trough the coal drops from the conveyor hopper (42) in front of the rear large plunger of the conveyor. On the forward motion this coal is forced along the bottom of conveyor trough (41). As the conveyor again goes to its back position the paddles are free to lift and ride over the coal; when it again goes forward, the paddles, being held by cross angle irons in the forward motion, dig into the coal and push it forward; the coal is then carried forward and dropped into the main hoppers (9), there being two of these main hoppers. The main hopper is provided with a 10-inch plunger which is connected to the main plunger cross bar (7).

The grate surface and the location of the two main hoppers and troughs are clearly shown on the end elevation.

Referring again to the vertical cross section: the coal is pushed into the hoppers by the main plungers and is assisted by the action of the auxiliary plungers (23) and the agitators (24) and is pushed in a forward and upward direction into a pile above the main hopper; from this point it drops sidewise on the sloping grates and is burned. The auxiliary plungers and agitators receive their reciprocating motion through connecting links (14) and (16); each of the connecting links (14) being connected to the lower end of the main connecting links (6), which have, due to the compound drive very nearly a horizontal motion.

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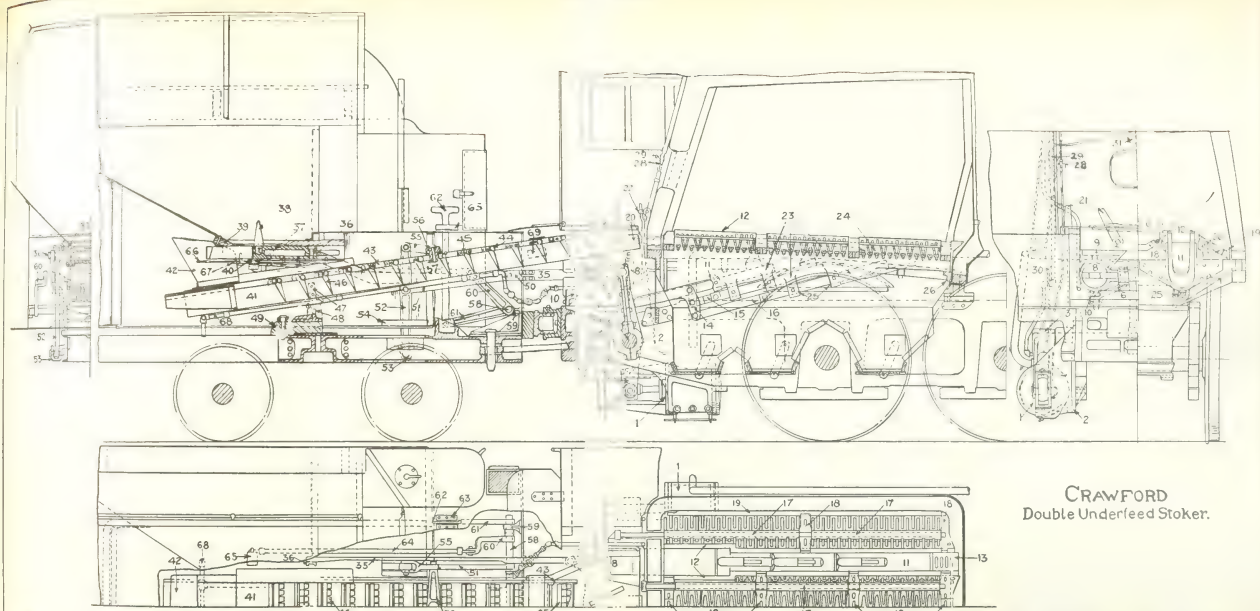


CRAWFORD
Double Underfeed Stoker.

1. Stoker Engine
2. Main shaft Bearing
3. Crank Arm
4. Main driving Shaft
5. " " Arm
6. " connecting Links
7. " plunger Cross Bar

8. Main plunger
9. " Hopper
10. " " Support
11. Trough
12. " dead Grates
13. " front dead Grates
14. Rear Aux. plgr conn. Links
15. Inter Aux. plgr conn. Links
16. Front " " "
17. Grates - Shaking
18. " Supports
19. " Side bearing
20. " shaking Shaft
21. " Shakers
22. Grate shaker Lock
23. Aux. Plungers
24. " " Agitators
25. " " Bushings
26. Front trough Support
27. Deck Grating
28. Air op'd Control Valve
29. Stoker Engine Valve
30. Governor
31. Patent Badge Plate
35. Long Driving Rods
36. Cr[illegible]gle Tree
37. [illegible]
38. [illegible]tors
39. [illegible]de
40. [illegible]m Plate
41. Cross [illegible]rough
42. [illegible]er
43. Paddle Carrier
44. " Rods
45. " Stops
46. Paddles
47. Trunnion
48. " Support
49. " " Bearing
50. Connecting Rod Lugs
51. " " Rods
52. Rocker Arm
53. " " Fulcrum Bkt
54. " " Guides
55. Single Tree conn. Links
56. Conveyer Single Tree
57. Single Tree Fulcrum
58. Coal Cut Off Op'g Shaft
59. " " " " Brgs
60. " " " Lever Arm
61. " " " " "
62. " " " " Handle
63. " " " " Guides
64. Coal Cut Off Connector
65. " " " Cross Bar
66. " " " Slide
67. " " " " Guides
68. Conveyer Radiator
69. Patent Badge Plate

ALLFREE SYSTEM OF STEAM DISTRIBUTION.

The Allfree system of steam distribution is designed to eliminate the wastefulness of locomotive cylinders. It is claimed that in standard locomotive practice a single valve, either of the piston or flat type, will perform only three of its four functions perfectly, viz.: admission, cut-off, and release; but the fourth, known as closure, or the compression event, is wrong. If the valve is provided with a sufficient amount of exhaust lap to obtain an economic expansion through delaying the release, the exhaust closure becomes excessively early, and an enormous clearance space must be provided equal to fully 15 per cent of the piston displacement. This entails such a loss that a compromise is generally effected by reducing the exhaust lap, making the release earlier but delaying the closure to a point, where not to exceed 10 per cent of clearance space need be provided. This requires a valve having its exhaust edges about equal to the exhaust edges of the ports, generally designated as line and line, or if the valve is cut a little shorter, giving say about one-eighth exhaust clearance, the clearance or waste spaces may be reduced to about 8 per cent of the piston displacement. Any further reduction of exhaust lap would result in a greater loss through an early release than would be gained through a reduction of clearance.

In the Allfree system a single valve correctly controls admission, cut-off and release the same as in the standard engine, except that a sufficient amount of exhaust lap is used to carry the steam to a point that will give a greater expansion. To avoid an early closure, a small piston valve, called the compression controlling valve, is introduced through a section of the ports beneath and to one side of the main valve, and has only the function of controlling the compression and providing greater freedom for the escape of exhaust steam. While the two valves release at the same instant, the compression valve in closing falls about one and one-fourth inches behind the main valve. This allows the exhaust steam, that would otherwise be in compression, to escape until the piston reaches about 90 per cent of its stroke (at ¼ cut-off) or within 2½ or 3 inches of the end of its stroke. The clearance having been reduced to 2½ per cent of the piston displacement, a sufficient amount of compression takes place to perfectly cushion the reciprocating parts.

The Allfree cylinders and valves for locomotives are claimed in point of efficiency to hold the same relation to standard locomotives as the Corliss does to the ordinary slide-valve engine in stationary practice.

The mechanical means employed are simple, the few special features being contained within the valve chambers of the cylinders. All that is necessary for an application of the system to a locomotive is to apply the cylinders in precisely the same manner as standard cylinders, connecting the valve stems to the standard rockers and making the usual adjustments. It involves substan-

tially a change of cylinders only. Any of the standard valve gears—Stephenson, Walschaert, etc.—may be used.

The following is a brief analysis of the results claimed and the means employed:

1. *Reduced Heat Losses.* The cylinders are designed with short ports and the exhaust passages carrying cold steam are separated and insulated from the live steam passages; consequently heat losses from radiation and condensation are greatly reduced.

2. *Less Steam Used for a Given Cut-Off.* The waste spaces in the cylinders are reduced to the minimum. In common practice this amounts to at least 10 per cent of the piston displacement, while the Allfree cylinders have not more than 2.5 per cent. To illustrate, for a 7-inch cut-off in a 30-inch stroke engine they, in effect, draw upon the boiler for 7¾ inches of steam, while for a like cut-off in a standard engine it will require an average draft on the boiler of 10 inches of steam.

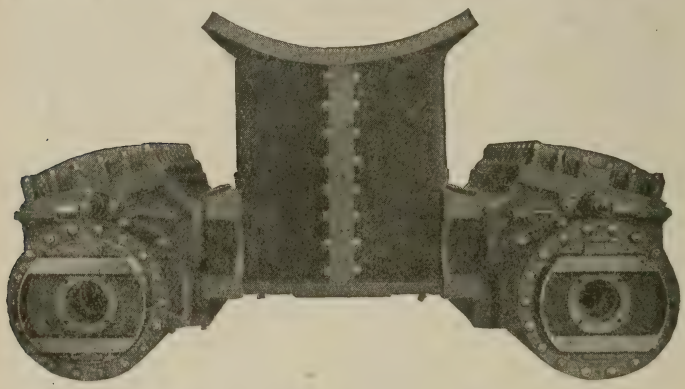
3. *Higher Ratio of Expansion.* Because of the minimum waste spaces in the cylinders and of the ability to hold the steam in the cylinders longer before exhausting it, a higher ratio of expansion is obtained—that is, more work—out of the steam admitted to the cylinders.

4. *Perfect Exhaust.* Having an increased exhaust area of about 50 per cent, this system produces a quick, extraordinarily free and large opening of exhaust, discharging the exhaust steam perfectly and quickly. This greatly reduces back pressure, or negative work, in the cylinders, and, due to the sudden release, a better fire is maintained, even with an enlarged exhaust nozzle.

5. *Reduced Negative Work.* In the return or exhaust stroke of the piston the exhaust is not closed until very late in the stroke; but when the proper point is reached, just enough exhaust steam is entrapped in the cylinders and small clearance spaces to produce sufficient compression to answer the mechanical needs of cushioning. In the standard locomotive the exhaust is closed comparatively early in the stroke and negative work commences correspondingly early. As the compression begins early in the standard engine, a large amount of clearance space must necessarily be provided to prevent compression running too high, and a correspondingly large amount of negative work must be done to compress the larger volume. Therefore, the negative work of compression with the Allfree cylinders is reduced enormously and a corresponding amount of available positive work is added.

6. *Increased Turning Effort.* It is found in locomotives where the power is applied to the drivers through rotative rather than reciprocating motion that such locomotives pull, without slipping

of the drivers, considerably greater tonnage than the standard locomotive of same weight. The reason for this is that the power is applied steadily in one case and intermittingly in the other. In the reciprocating engine, if the release is early and an unnecessary resistance set up on the opposite side of the piston, more steam must be applied in the center of the stroke to make up for losses at each end. Consequently the power is applied to the drivers intermittently, producing a jerky effect, and the limit of adhesion of the drivers is reached long before the real power of the engine can be used. But under the Allfree system, by holding on to the steam longer at one end and by removing the resistance at the other end of the stroke, higher average pressure will result and the power distributed more evenly through the stroke,



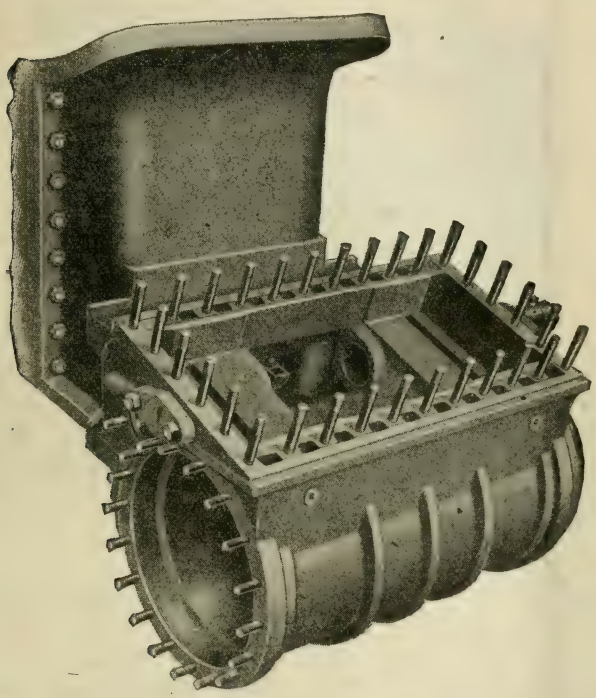
thus imparting to the drivers a steadier or more even rotative effect, increasing the available power of the engine and greatly decreasing tendency of slipping.

GENERAL ARRANGEMENT OF PARTS

The general arrangement of valves, valve chambers, steam chest covers, etc., is shown in Figs. 1 and 2.

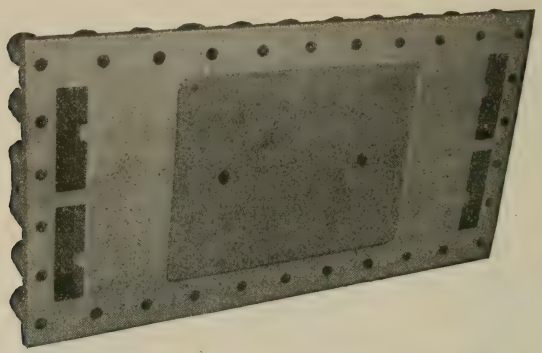
The steam chest or main valve chamber is on an angle of 15 degrees with the horizontal and placed close to the cylinder bore. The ports are short and practically straight, so that their surfaces may be scraped clean and smooth. The compression controlling valve chamber passes through the longest section of the ports, and is bushed in the usual way to provide for repairs. The steam chest cover forms the top side of the main valve chamber and provides a by-pass connection between the exhaust passages which equalizes exhaust pressures.

The main steam valve is of rectilinear form, rigidly constructed and designed so that the wear is uniform, regardless of the travel. It is balanced for all speeds and under all pressures, running or drifting, and with its wearing surfaces nearly doubled by special riding shoes, the wear on the valve and valve seat is very slight.



This illustration shows the Cylinder with Steam Chest Cover and Valves removed. As will be seen, the Cylinder and Valve Chamber or Steam Chest are one casting; the ports are short and practically straight with the Compression Valves passing through their longest section. The admission is from the inside which brings the live steam in contact with a considerable portion of the Cylinder walls, while the exhaust is at the ends and is most effectually insulated from the live steam, thus eliminating one of the greatest sources of heat loss. Double walls are used around all live steam passages wherever practicable with the object of making the insulation as perfect as possible. This design produces an exceptionally strong cylinder well adapted to resisting shocks which would often destroy cylinders of the ordinary design.

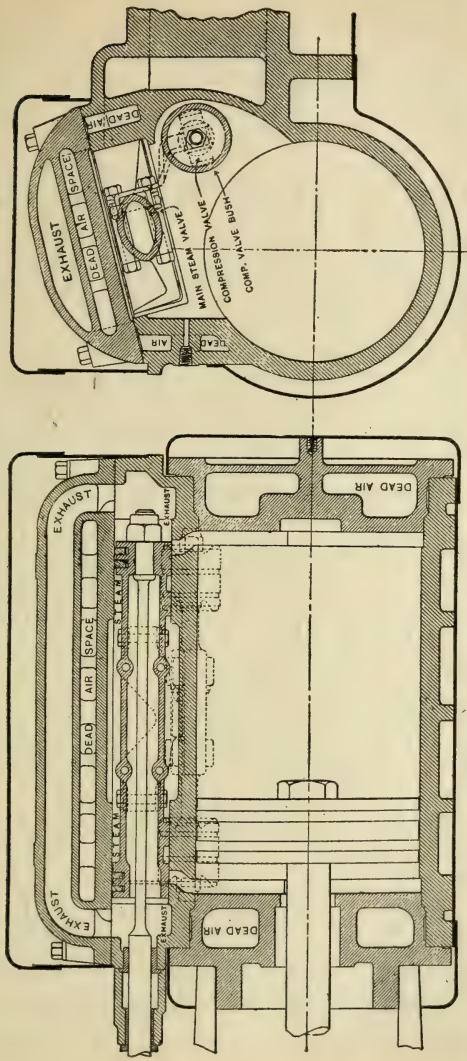
The compression controlling valve is a piston valve of the usual design, except that it is very light and provided with wide snap rings to overlap the ports and for protection against wear. It takes its motion from the main valve by means of an arm connection of rigid construction.



The Combined Steam Chest Cover and Pressure Plate, as shown by the cut, has a by-pass chamber connecting with each end, thus permitting a portion of the exhaust from one end to flow through the exhaust passages at the opposite end, which greatly aids in preventing the induction of cinders into the cylinder when drifting. Between this by-pass chamber and the face of the cover a dead air space is provided, insulating the live steam from the exhaust steam, while the exhaust steam, passing through the by-pass, insulates the dead air chamber from the atmosphere, which is somewhat further shut off by the usual cylinder casing. The cover also serves as a Pressure Plate for the Main Valve.

The admission of steam to the cylinders and the cut-off is controlled by the main steam valve. Steam is admitted along the entire lower edge and up one side, providing an unusually large port area for admission. Exhaust also is controlled by the main steam valve, but to this is added the exhaust of the compression controlling valve, which releases simultaneously with the main valve.

Closure or compression is controlled entirely by the compression controlling valve, which delays the final closure of the exhaust until the piston has completed 90 per cent of its stroke at the short cut-offs, thereby reducing the volume of the exhaust steam in compression from about 10 inches in the usual practice to 2¾ inches in this system.



LONGITUDINAL SECTION.
Fig. 1

TRANSVERSE SECTION.
Fig. 2

SETTING LOCOMOTIVE VALVES.

The following concise explanation of valve setting is given by an authority on the subject*:

Setting the valves of a locomotive is nothing more or less than setting the valves of four ordinary slide-valve stationary engines, two to run in one direction and two to run in another or opposite direction. There is, however, an obstacle to easy and quick setting in the locomotive not usually found in a stationary engine—namely, the *link*.

There are four stages in the operation of a slide-valve and piston while making one stroke, viz.:

Admission of steam to cylinder.

Cut-off of steam from cylinder.

Release of steam from cylinder.

Compression of steam in the cylinder by reason of the exhaust closing before the piston reaches the end of the stroke.

Cutting off short means exhausting too early, and there is a limit to the point of cut-off where economy is an object.

Shifting Link.—With a shifting link the lead of the valve increases as the reverse lever is hooked back, or as expansion increases, and a valve to which no lead is given when it is set will gain about

* D. B. Dixon.

3-32 of an inch when the lever is hooked back into the 3-inch notch.

Stationary Link.—With a stationary link, where a radius-bar is used to connect the link-block to the lower rocker-arm, the lead never changes; it is constant at any point of cut-off.

The reason why a shifting link changes the lead and a fixed link does not is owing to the angularity of the eccentric-rods changing by shifting the link, as may be determined by shifting the link to cut off at, say, 6 inches, and then, the engine being in the forward motion, disconnecting the go-ahead eccentric-rod and lowering it with the eccentric in different positions; it will be noticed that as the lever is hooked back the rocker-arm must be moved more or less in order to again make the connection. Moving the rocker-arm necessarily moves the valve; moving the valve alters the lead. With a fixed link the angularity of the rods is the same always, as the link is not raised or lowered.

Should the valves not come square, the fault may lie in the point of suspension of the link; or the reverse shaft may be too close to, or too distant from the rocker-shaft; or the reverse-shaft lifters may not be of equal length, or one may be higher or lower than the other, or both too high or too low; or the reach-rod may be too long or too short; or the link may not be an arc true to its proper radius.

Throw of Eccentric.—The rule for obtaining the throw of eccentric, or travel of valve, is as follows:

Rule.—It is found by adding together the width of both steam-ports, and the lap on both ends of the valve; this product will give the exact opening of steam-port, about three-quarters of an inch

more being added to the above product so that the edges of the valve will travel about a quarter of an inch beyond the inside edge of steam-port, on the bridge, which is termed over-travel, and gives more opening of port when working in back notches.

EXAMPLE.

	Inches.
Width of front port	1¼
Width of back port	1¼
Lap of front end	1
Lap of back end	1
Over-travel	¾
Total travel of valve	5¼

The throw of the eccentric of a stationary engine is equal to twice the lap on the valve, added to twice the width of steam-port; but with a locomotive this will not be sufficient, owing to cutting off with the link. To illustrate: Take a valve-seat 10½ inches long, steam-ports 1¼ inches long, exhaust-port 2½ inches long, bridges 1 inch long; valve 8½ inches long, valve cavity 4½ inches long; throw of eccentric 5 inches; end travel of valve 5 inches; lap on valve ¾ inch; lead nothing.

(*Note.*—In giving valve-seat dimensions the length of seat, bridges, and ports is assumed to be in the direction of motion of the engine, and *not* in the direction of cross section of cylinder.)

In order to give a full port opening, with the link in full gear, the stroke of the valve need not be more than 4 inches—that is, twice the lap = 1½ inches, twice the width of steam-port = 2½ inches; but in working expansively, with the lever hooked back into the last cut-off notch, the valve would not have travel enough to give a steam-port

opening with a 4-inch throw of eccentric, consequently the travel must be increased in full gear more than is necessary in order to get a port opening when cutting off short. In order to do this the eccentric should be given 1 inch more throw, or 5 inches instead of 4, and the valve travel made half an inch past the inside edge of the steam-port when the link is in full gear.

In cutting off short, the exhaust opens too soon and releases the steam before it has done its full duty; this could be remedied by shortening the exhaust cavity of the valve, or, in other words, giving plenty of inside lap. But if inside lap is given to delay the exhaust opening on one end of valve the exhaust is closed too soon at the other end, and perhaps no exhaust opening at all given if cutting off at the shortest point. This indicates that the link is not a perfect device for working steam expansively.

Saddle-Pin.—The saddle-pin centre is not usually placed where it would seem naturally to belong—that is, directly over the arc of the link—but outside the chord of the arc in most links. The purpose of this is to counteract the slip of the link.

Line of Centres.—In link-motion much is gained by preserving as far as possible a line of centres. For this reason, in the link before mentioned, the centre of saddle-pin is placed several inches above its natural position, or at such point as would bring the centre of eccentric-rod pin, and the centre of link-block and centre of saddle-pin as near to each other as possible. By raising the saddle-pin as described, its centre and that of the link-block are brought in line, and knuckling of the link is in a great measure avoided while the reverse-

lever is in the cut-off notch in which it is most generally carried.

Length of Link.—The length of link is not governed by the space under the boiler for raising it, but by the travel of valve; as should the link be made too long, and the sector notched accordingly, in full gear the valve would travel off its seat, supposing the seat to be properly proportioned. But should the link be too long, and the sector notched for a link of proper length, the valve would travel all right.

Travel of Valve.—The travel of slide-valve and the *stroke of a slide-valve* mean the same thing, although if spoken of with reference to the stroke of the piston the *travel* of the valve might be said to commence with the piston just finishing its stroke, or, if no lead is given to the valve, just as the piston has finished its stroke.

Assume a valve of the following dimensions: Length of valve, 8½ inches; length of cavity of valve, 4½ inches; lap, ¾ of an inch; no lead. Valve-seat, 10½ inches long; length of steam-ports, 1¼ inches; length of bridges, 1 inch; length of exhaust-port, 2½ inches; length of seat-faces, 1¾ inches; travel of valve, equal to throw of eccentric, 5 inches. When the crank is on its dead centre, and the piston at the end of the cylinder, or end of its stroke, the end of the valve is at the outside edge of the steam-port. The piston begins to move towards the other end of the cylinder; at the same time the valve begins to move in the same direction, and continues moving until the end just referred to reaches the middle of the bridge, when it begins its return movement. The valve has now traveled 1¾ inches. Continuing

its return movement (the piston is still going in the direction in which it started), it advances until it arrives at a point 3¼ inches from the middle of the bridge. At this instant the other end of the valve is at the outer edge of the opposite steam-port, *and the piston has completed its stroke.* The valve still keeps moving on its return until the end reaches a point 5 inches from the middle of the bridge first referred to, when the opposite end of valve is in the middle of the opposite bridge and the travel is completed. The first part of this valve movement might properly be called "travel," and the last part "stroke."

The Eccentric.—An eccentric is but another form of crank, and its function is the same—that is, to give a backward and forward or reciprocating motion. If we make an eccentric of 5-inch throw we simply make a crank, the distance between the centre of the axle or shaft bore of which and its wrist-pin bore is 2½ inches. Such crank would give a 5-inch stroke; such eccentric gives just the same stroke—that is, 5 inches. The difference between the two is that the eccentric can be used on a locomotive-axle or engine shaft when the crank cannot, otherwise the crank might often take the place of an eccentric so far as cheapness is concerned.

The eccentric is "eccentric" by the amount that the centre of axle or shaft bore is distant from the centre of the eccentric. If these centres are 2¼ inches apart the eccentric has a 4½ inch throw; if 2½ inches or 2¾ inches apart, the eccentric has a 5-inch or 5½-inch throw, and so on.

Cam.—A cam and an eccentric should not be confounded as their motions are not precisely the

same; it is as improper to call a cam an eccentric as to call an eccentric a cam.

Inclined Cylinders.—Some locomotives have inclined cylinders. When such is the case, and the valve-seat inclines also, or when the valve-seat and the longitudinal axis of the cylinder are in the same plane, but at an angle with the frame, the lower rocker-arm must be set back in order to connect the link to the eccentric-rods, and that the end travel of the valve may be same for both ends of the valve.

If the cylinders incline, and the valve-seat be made horizontal or parallel with the frame, the arm need not be set back. Cylinders with the bore and valve-seat at an angle are sometimes put on locomotives. In the case given above, lengthening the eccentric-rods would not do, although it would enable a connection to be made with the link.

Angularity of Eccentric-Rods.—The motion of a link is quite complicated, owing to the many and different angles made by the eccentric-rods with the plane of motion of the driving-axles, and with each other, during one revolution of the eccentrics.

Angularity of Main Rods.—The different angles formed by the main rod with the crank while the latter is making one revolution is another source of trouble in determining relative positions of piston and valve, or of two pistons, of an engine. If the crank is set plumb, the piston will not be in the middle of its stroke; if the crank-pin is above the axle the piston will be past the middle of the stroke; so, also, if it is below, as the main rod is the hypothenuse of a right-angled tri-

angle, and consequently the longest side of the triangle formed by the rod, the crank, and the axis of the cylinder, or the plane of motion of the center of the axle. If the crank-pin end of the rod be disconnected and dropped down to the centre of the axle, it will be found that the centre of the brasses is beyond the axle-centre; and if the piston be moved into the middle of its stroke, and the rod raised to make connection with the crank-pin, it will be found that it cannot be done, as the end of the rod will not reach the pin.

RAGONNET POWER REVERSING GEAR

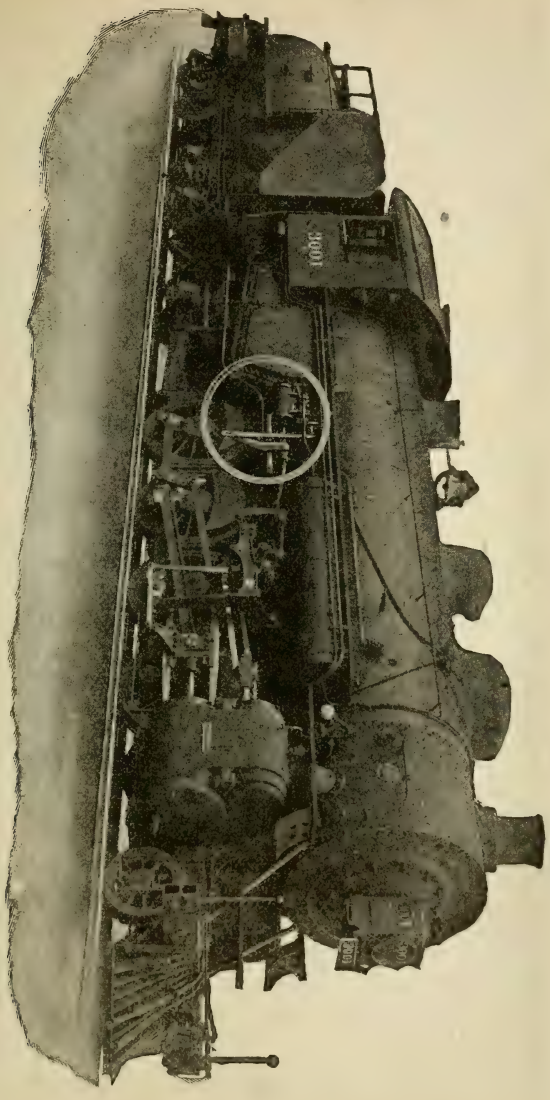
The power reverse has come to be recognized as almost a necessity on the heavy locomotives now in common use.

The difficulty, not to say danger, in hooking up passenger engines while running at high speed, may lead to the practice of controlling the engine by throttling instead of by the cut-off, which is not conducive to economy. The power reverse, making it easy and safe to alter the cut-off while running at the highest speed, is thus a great factor in the economical use of steam.

The power reverse is also coming into use for switching engines, both heavy and light, on account of the great increase in capacity made possible by the easy handling of the reverse lever. On switch engines with ordinary hand lever the day's work is frequently limited by the engineer's ability to withstand the fatigue incident to the constant handling of the lever. Thus the power reverse has been the means of greatly increasing the capacity of switching engines.

The accompanying illustrations represent a well known power reverse gear, the invention of Mr. E. L. Ragonnet. This device has passed through the experimental stage and is presented as a thoroughly practical solution of the power reverse gear problem.

The gear is preferably operated by air, although an auxiliary steam connection is provided. Distribution is controlled by an ordinary D slide valve arranged for outside admission. The piston rod is connected to a crosshead, which is coupled to the reverse shaft by means of a suitable reach rod. The crosshead gibs are held in place by a cast steel plate having an arm projecting downwards. This crosshead arm is connected by a suitable link with the lower end of a floating lever. The upper end of this floating lever is pivotly connected to, and



Ragonnet Power Reverse Gear

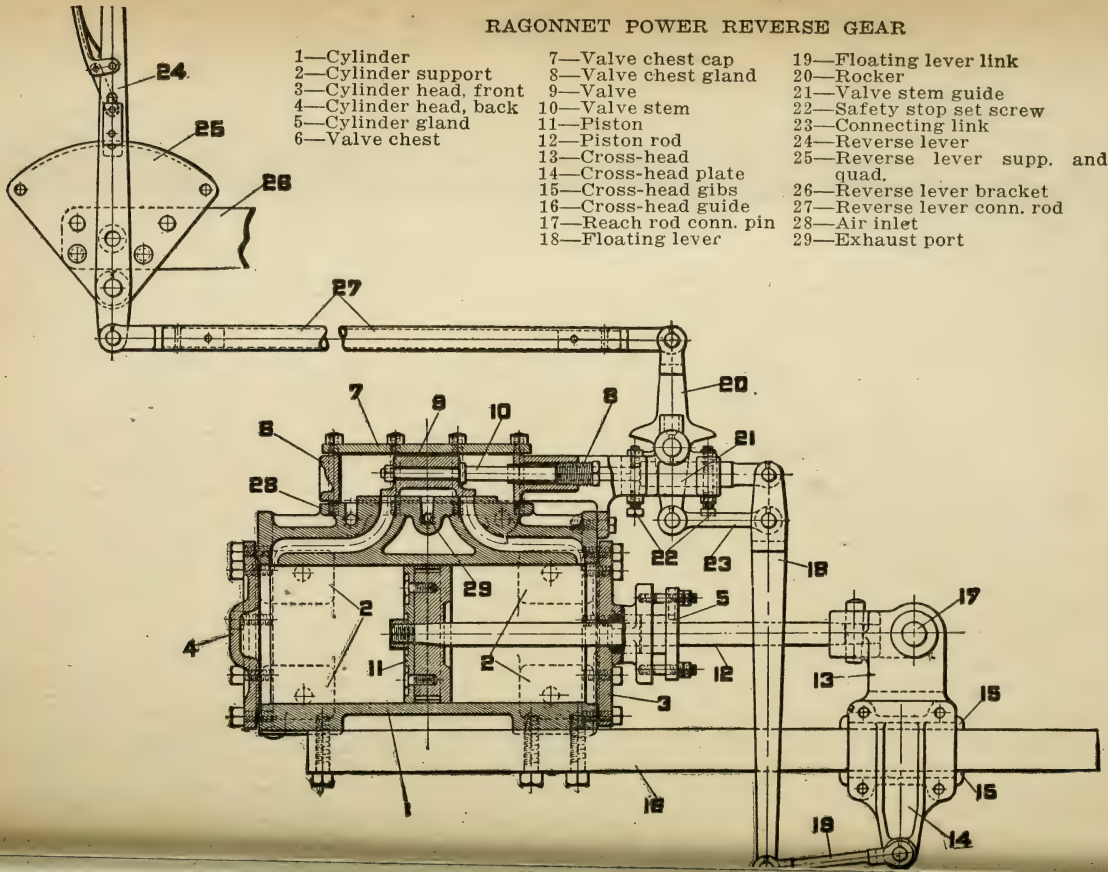
supported by the valve stem, which in turn is carried by a cylindrical guide. Through the agency of a rocker, the upper end of which is connected by a light rod with a small reverse lever, and the lower end through a link with the floating lever a short distance below the valve stem, the movement of the valve is controlled from the cab. The rocker is provided with tappets which strike the ends of projecting set screws when the limit of travel of the valve is reached. These set screws require no adjustment after the gear is properly applied, and merely limit the throw of the reverse shaft arm in either direction.

The small reverse lever is locked in any desired position by an ordinary toothed quadrant. Assuming the lever in mid position and the valve normally covering both ports; when the lever is moved into forward gear (to the right, referring to the drawing) the floating lever swings about its lower end as a fulcrum, and the slide valve is moved to the right, admitting air to the left-hand end of the cylinder. The piston now moves to the right, and the floating lever, pivoting about its intermediate, or reverse-lever connection, returns the valve to its central position unless the progressive movement of the reverse lever is continued. Thus it will be seen that when the lever is shifted to any desired location, the piston moves in the proper direction until the valve gear reaches a corresponding point, whereupon the valve is automatically returned to its central, or lapped position.

Since the exhaust, or inside lap of the valve is materially greater than the outside lap (which is very small) air is held on both sides of the piston at the same time. It will thus be seen that the mechanism is prevented from creeping or vibrating by an elastic cushion formed by compressing the air in one end of the cylinder or the other. In no case does the valve open to exhaust when holding the gear in any desired cut-off position. Owing to this arrangement the gear is very economical of air—in fact, when piston and piston-rod packing are properly maintained, the loss of air, when holding the valve gear in a fixed position, is practically nil. The holding of the valve gear through the medium of an air cushion instead of by a rigid latch and quadrant, materially

RAGONNET POWER REVERSE GEAR

1—Cylinder
2—Cylinder support
3—Cylinder head, front
4—Cylinder head, back
5—Cylinder gland
6—Valve chest
7—Valve chest cap
8—Valve chest gland
9—Valve
10—Valve stem
11—Piston
12—Piston rod
13—Cross-head
14—Cross-head plate
15—Cross-head gibs
16—Cross-head guide
17—Reach rod conn. pin
18—Floating lever
19—Floating lever link
20—Rocker
21—Valve stem guide
22—Safety stop set screw
23—Connecting link
24—Reverse lever
25—Reverse lever supp. and quad.
26—Reverse lever bracket
27—Reverse lever conn. rod
28—Air inlet
29—Exhaust port



lessens the wear and tear of the valve gear and its connections.

The cylinder is oiled through a small lubricator, conveniently placed in the cab, and suitable means of lubrication are provided on all moving parts.

The entire mechanism is so simple in construction, and has proved so reliable in service, that, as a rule, no auxiliary hand gear of any description is applied.

MELLIN POWER REVERSING GEAR

A power reversing gear is generally applied to Mallet and heavy Mikado locomotives to operate the reverse lever. This device consists of an engine of two cylinders, one for air and the other filled with oil. The two cylinders are set one ahead of the other, the pistons being mounted on a common piston rod connected either directly or indirectly to the main reverse lever.

The arrangement and construction of this mechanism is shown in Fig. 1 on the following page. In this case the forward one is the air cylinder.

The pistons of both cylinders are provided with leather packing, that in the air cylinder being held out by spring rings. The cylinders are operated by conical valves, the construction of which is shown in the detail illustration.

These valves are operated through a connecting rod by an auxiliary lever (R) pivoted on the main lever (Q).

By an interlocking arrangement, the latch of the main reverse lever is loosed by raising that of the auxiliary lever and cannot drop until the two levers are in their normal position to each other.

Ordinarily, the valve motion is handled entirely by the auxiliary reverse lever. Consequently, the main reverse lever is usually not brought above the deck of the cab, thus leaving more room for the engineer. A separate handle, easily attached, is provided for the main lever for use in case of emergency.

The auxiliary lever is handled exactly the same as the main reverse lever would be except that of itself it only has

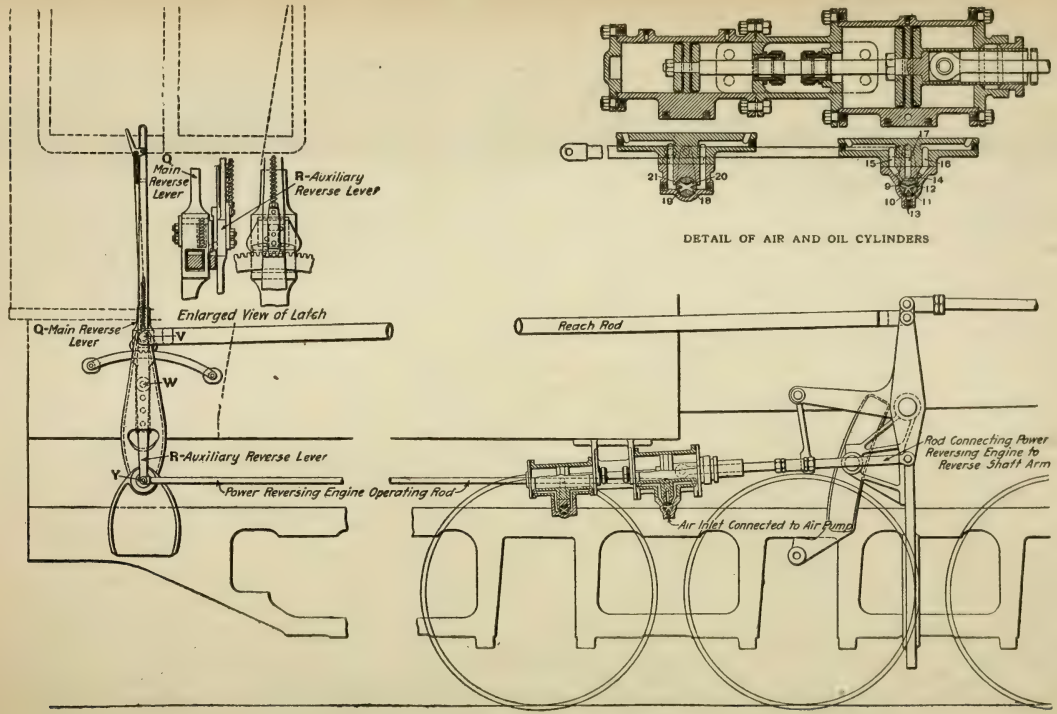


Fig. 1—Mellin Power Reversing Gear

a limited throw about its pivot point on the latter. This slight movement operates the valves in the reversing engine and the valve motion is moved in the desired direction. When the required notch in the quadrant is reached and the auxiliary lever latched, the gear automatically restores the main reverse lever to its normal position relative to the former. This permits the main lever to engage with its quadrant and also closes the valves of the reversing engine, thus giving both a positive and an oil lock to the gear.

The oil cylinder prevents the too rapid movement of the reversing gear when a change of cut-off is made. It is imperative, therefore, that the engineer should see that this cylinder is always kept full of oil. The frequency with which it should be filled depends on the condition of its piston and piston-rod packing, and these should therefore be kept in good repair. If the reversing gear operates too rapidly, this indicates that the oil cylinder needs refilling, and this should be done, and any leakages stopped as soon as possible.

After any overhauling of the reversing engine, particular care should be exercised to see that the valves are properly set so that the valve openings and cylinder ports match up correctly.

If the power reversing gear fails to operate when the valves are supposedly opened and nothing has happened to the air supply, first examine the valves to see that they are in their proper position.

If the main lever does not latch properly, which might happen because of lost motion in the gear after long service or because of improper adjustment in setting up the gear after repairs, the engineer should report this matter at once. Under such a condition, the latch of the auxiliary lever would have to resist any pull that comes on the levers with the result that it would wear more quickly.

BRAKE SHOES.*

The subject of shoes is ordinarily considered a prosaic one; but as foot wear for mankind must be adapted to the various requirements to be met with, so must the brake shoe "fit" the service required. The man with sharp nailed logging boots would be no more handicapped in wearing them in the ball-room than would be the dancer with his patent leather "pumps" in a log-rolling contest.

The same air pressure applied to the various wheels of a locomotive or train where brake shoes of different hardness are used will produce a widely different friction as well as tire-dressing effect on the various wheels. Before the maximum braking power could be obtained from the friction of the hard cast iron shoes, the wheels having softer shoes applied would be sliding. Sliding wheels not only cause damage to themselves but while sliding reduce the retarding effect for which the brake exists. Hence the only way to obtain the fullest degree of brake efficiency is to have a uniform hardness of the brake shoe on each wheel.

Brake shoes are made for three kinds of service, namely:

(1) Steel-tired driving wheels, (2) chilled cast iron and (3) steel-tired car, engine truck, and tender wheels.

*The subject of brake shoes is also treated of in the volume, "Cars—Their Construction and Handling."

The brake shoe for locomotive driving wheels must be one that not only will produce the necessary friction for braking purposes but also dress off that portion of the tire which is not worn down by contact with the rail. Small-wheeled freight and suburban passenger engines necessarily require a brake shoe that will cause greater tire dressing than that necessary for the large driving wheels of express locomotives.

It has been said with reason that work on driver and tender brakes that will enable them to wear out brake shoes is more to be desired than quick-acting triple valves, and it is safe to assume that the brake which does not wear out shoes in a reasonable time is doing but little work; before all other considerations the brake should have proper holding power.

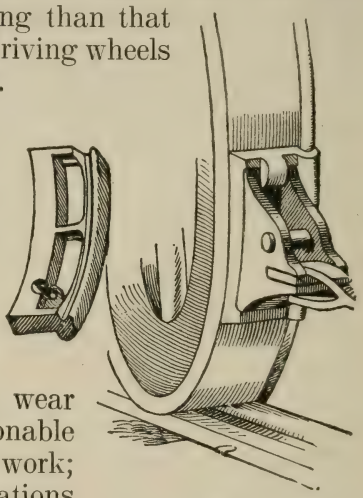


FIG. 1.
Brake Shoe and Its Application to the Driver.

The primary point in the consideration of a brake shoe is friction, and next to this the effect of the shoe upon the tire. The experience of railroad men in general and the results of various tests show that steel acts more effectively on the tire than chilled or unchilled cast iron, and for this reason shoes of steel, or steel and iron, for locomotive service, are the most efficient and popular.

The last point to be considered in the brake shoe and

one which is of the least importance in comparison with the other two (although oftentimes overlooked by the purchasing agent in his zeal for cheapness), is the life of the shoe, or its durability.

The brake shoe which lasts the longest is liable to be the one which does the least work. It can be shown that by reducing the brake pressure, the same result is accomplished as would occur from making the shoe very hard.

The shoes for locomotive service are:

First, the driving brake shoes, which are required not only to hold the wheel but also to cut down the tire where it is not acted upon by the rail.

Second, the leading truck and tender shoes, which while giving good frictional effect should not act so severely upon the tires, because of the reduced action of the rail in wearing into the tires. However, the shoes for the leading truck should cover not only the outer tread but the flange also of the wheel in order to reduce to a minimum the tendency to sharp flanges. The tender shoes, if used on steel tires, should preferably be made of the same design, although the tendency toward wearing the wheel flanges sharp is not so great as in the case of the engine truck. The shoes in each case should have good frictional effect consistent with the proper action on the tires.

THE SARGENT BRAKE SHOES.

The Sargent brake shoes, made under license from the American Brake Shoe Company, are described as follows:

Locomotive Driving Brake Shoes. — First, the

skeleton steel brake shoe, Fig. 2, is a casting of mild steel, the metal of which is so disposed as to cover as much as possible those parts of the wheel tread which are not acted upon by the rail. Steel is the most effective metal for wearing down the tire and in the skeleton steel brake shoe the right metal is properly designed for the service required. The material possesses high frictional power and a strong wearing action on the tire, and, as distributed in the skeleton design, cuts away the outer tread and top of flange, thus tending to maintain the original tire outlined. Shopping engines for tire turning is largely prevented or delayed by the use of the steel shoe, and the expense of locomotive maintenance considerably reduced. The skeleton steel brake shoe is strongly recommended for freight, switching and suburban service, and where tires are rapidly worn into by the action on the rail.

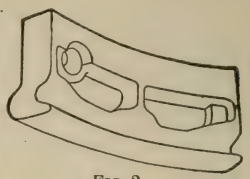


FIG. 2.
Skeleton Steel Brake Shoe.

The Skeleton Steel Insert Shoe, Fig. 3, is recommended for general locomotive service. It is not so severe a tire dresser as the all-steel shoe, but is more generally used. It consists of a body of cast iron having inserts of a special crucible steel disposed along the face of the shoe where it contacts with the tire outside of the limits of rail wear. These inserts remain constant, being unchanged by the heat of friction, presenting hard and uniform cutting edges

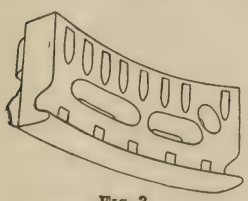


FIG. 3.
Skeleton Steel Insert Shoe.

which are exposed by the grinding away of the cast iron between them, and act like milling tool cutters in dressing down the tire. The skeleton design removes much of the shoe metal from against the throat of the wheel flange and over the line of rail wear; the broad surfaces of soft cast iron at each end of the shoe and the large area surrounding the inserts afford ample holding power, while the inserts by their hardness insure durability and cutting action on the tire.

The skeleton steel insert shoe is designed for all classes of locomotive service and its use insures increased engine mileage between tire turnings and increased brake efficiency.

The Improved Combination Brake Shoe, Fig. 4, is designed for those who desire great durability combined with wearing action on the tire. It consists of a body of cast iron having high chilling properties; diagonal grooves along the outer tread, and depressions in the flange-bearing portions made by metal chill blocks, provide sharp edges for cutting down the tire; across the face of the shoe and over the limits of the rail wear upon the tire, are alternate areas of chilled and soft metal, the former to reduce to a minimum the abrading action of this portion of the shoe face upon the tire, and the latter to provide frictional effect. The combination of cutting edges and hard and soft surfaces of contact being such as to provide an equality of brake shoe action upon the tire, so as to prevent uneven wear. This brake shoe is in extensive use and proves a most durable and economical shoe.

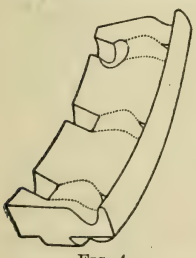


FIG. 4.
Improved Combination Driving Brake Shoe.

Engine Truck and Tender Brake Shoes.—The Skeleton Diamond "S" Brake Shoe consists of a body of soft cast iron surrounding and permeating a bundle of expanded sheet steel, as shown by Fig. 5. The shoe is especially designed to give a mild uniform dressing action upon the outer tread and the top of the flange in order to keep up with the wear of the rail into the tire and to perpetuate as long as possible the original shape of the wheel tread. The combined structure of steel and cast iron makes a very strong shoe with a composite face in which strands of mild steel bind the cast iron in all directions. The toughness of the steel retards the rapid grinding away of the cast iron without materially reducing the frictional effect, with the result of increasing the life of the shoe over that of plain cast iron without sacrifice of holding power.

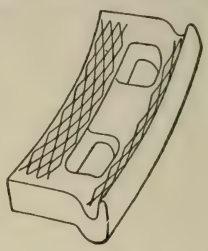


FIG. 5.
Skeleton Diamond "S" Brake Shoe.

The use of this brake shoe on truck and tender wheels, as well as the steel-tired coach wheels, means greater mileage from the tires, increased efficiency in brake action, together with a reduction in the total cost of operation.

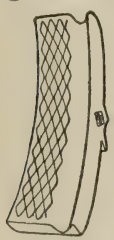


FIG. 6.
Unflanged Diamond "S" Brake Shoe.

The Unflanged Diamond "S" Brake Shoe is a reinforced cast iron shoe, as shown by Fig. 6. It is simply a block of soft, strong iron cast about a bundle of strips of expanded sheet steel. The combination forming a solid, homogeneous mass in which the steel is not fused by the iron, but retains its toughness and strength, and on account of

the bonded structure of the shoe, holds it together so that it can be worn down much thinner than the plain cast iron shoe without danger of fracture. The durability and strength of the Diamond "S" shoe insure a reduction in cost with an improvement in the brake efficiency.

The "U" Brake Shoe, as shown by Fig. 7, is designed to provide a shoe with the maximum durability with a constant and uniform action throughout its entire life, without injurious effect on the wheel; and to secure this extra endurance at as little expense of holding power as possible.

FIG. 7.
The "U" Shoe.

The idea is to take a soft cast iron shoe and add metal to the ends beyond the limits of the ordinary M. C. B. shoe, hardening these ends from the back in such a manner that the chilled or unchilled portion merges into the softer iron before reaching the surface of the shoe exposed to wear against the wheel at the beginning of service. So that at the start the whole area of contact of the "U" Shoe is of soft, unchilled iron equal to the face of the Standard M. C. B. Shoe. As the shoe wears down the hardened ends come into play to increase its life and these hardened ends, while delaying the rapid wear of the soft cast iron, increase the bearing surface of the shoe upon the wheel, making up somewhat for the decrease in frictional effect.

The location of the hardened ends of the "U" Shoe are outside the limits of the M. C. B. brake head and in no way diminish the strength of the shoe. The

ordinary type of chilled brake shoe is very liable to break in service on account of the strained condition of the metal, due to the chilled sections or inserts. This strained condition is entirely removed in the construction of the "U" Shoe; which is used on tender, coach and car wheels where great durability is desired.

THE LAPPIN BRAKE SHOES.

The recent development in the line of improvement in brake shoes has been, not so much in the creating of new forms or types, as in the modification of existing types to insure the practical wearing out of all or nearly all of the metal in the shoe, and thereby eliminating the brake shoe scrap that has in the past contributed so large a proportion to the waste of metal that makes up the scrap heap in railroad yards.

The first marked advance made in this direction was with the steel or malleable metal back shoe patented by H. B. Robischung in 1893, and since acquired by the Lappin Brake Shoe Company. In addition to this malleable metal back this shoe is now being furnished with malleable hooks and lugs on types of shoes where they form part of the device for attaching the shoe to the brake head.

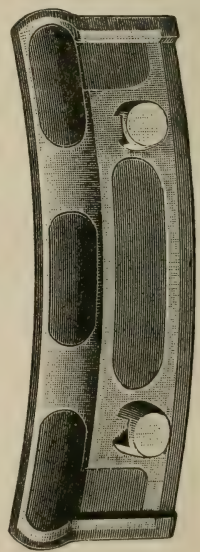


FIG. 8.
Lappin Driver Brake Shoe, with Malleable Back and Lugs.

Fig. 8 illustrates a driver brake shoe having malleable or steel back

and lugs, as described. With this construction, the shoe can be worn down with perfect safety to this back which is about one-fourth of an inch thick, thereby reducing the scrap loss by more than fifty per cent., and the hooks or lugs, being of malleable metal, cannot break, as sometimes happens when they are of common cast iron or of the same material as the body of shoe.

Fig. 9 gives two views of the now standard Lappin car shoe of the M. C. B. type with steel back, one showing the back of an unbroken shoe and the other a face view of shoe broken in pieces to show the grip of the metal in body of shoe on the metal back. The pieces are held so firmly to the back that if the shoe from any cause should crack or break, in several pieces, it can still be worn out with entire safety.

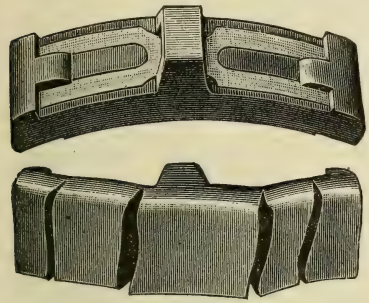


FIG. 9.
Lappin Car or Tender Brake Shoe.

Fig. 10 shows a malleable metal or steel back extending over the lug on back of shoe, and through which passes the key that secures the shoe to brakehead. This lug, when formed of the cast metal integral with the body of the shoe, is liable to break, in which case the shoe is at once detached from brake head and falls off; but with the malleable metal back extending over

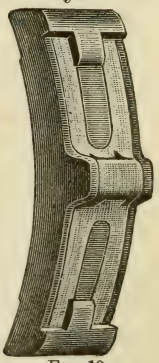


FIG. 10.
Lappin Brake Shoe.

and forming the lug, it is impossible for the shoe to break at this point and fall off.

Fig. 11 shows the back and face view of the interlocking shoe, the latest development in brake shoe improvements, which it is claimed will *entirely* eliminate the brake shoe from the scrap heap, as this shoe wears entirely out in the service, leaving no scrap that can be found. It can be furnished in the ordinary soft iron brake shoe mixture, to roads that so prefer it, or it can be furnished with inserts in the face for use on chilled wheels, or it can be chilled in sections in conformity with the Lappin standards for use on either chilled or steel tired wheels, the inserts of the chills very greatly increasing the life or wearing qualities of the shoe.

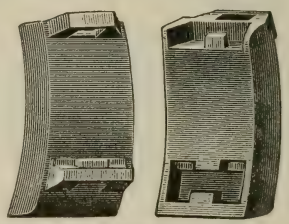


FIG. 11.
Interlocking Brake Shoe.

When first applying this type of shoe, what is known as the plain-faced type without any interlocking recesses cored in the face is used, and when this shoe has worn down to about five-eighths of an inch in thickness, or to the point at which ordinary cast iron shoes are scrapped, it is removed, and by the interlocking device on its back it is secured to the face of a new pocket-faced shoe, and the whole is then again reapplied to the brake head with the new pocket faced shoe next to the brake head, and the remaining unworn part next to the wheel, as shown in Fig. 12.

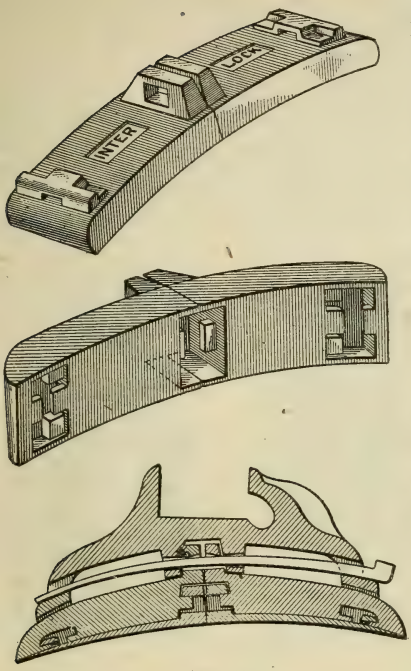


FIG. 12.
The Interlocking, Divided, Brake Shoe.

This shoe is cast in two parts, each about seven inches in length, and these short segments at once adjust themselves equally well to wheels from thirty-three to thirty-six inches in diameter, and thus obviate the necessity of carrying a stock of shoes for these different sizes of wheels. The remaining unworn part of the old shoe, when again attached to the face of a new shoe, always presents a surface exactly conforming with the radius of the wheel against which it had been previously applied.

THE CORNING BRAKE SHOE.

As the result of an extended study of the requirements of a brake shoe suitable for both steel-tired and chilled wheels, the Corning Brake Shoe Company presents another type of brake shoe. The materials used in its construction, soft cast iron and chilled iron,

were selected as being the only common metals which do not injure steel tires. No steel or wrought iron is used in Corning brake shoes.

Reference to the accompanying engravings will show the Corning brake shoe for locomotive driving wheels and the plain shoes for cars and tender wheels. These are all similar in having the main body of the shoe of tough, hard iron cast about a

FIG. 13. Corning Soft Gray Iron Insert.

FIG. 14. Corning Driver, Brake Shoe.

FIG. 15. Corning Plain Brake Shoe.

soft gray iron core, shown in Fig. 13; the body of the shoe has a chilled face. The sides of the soft iron inset are so tapered from the back to the face of the shoe that, after the body is cast about it, a section through the shoe shows a dove-tail joint. The advantage gained by this combination is that the long life of the chilled iron is obtained, while at the same time the soft iron gives to the shoe frictional qualities equal to those of the ordinary cast

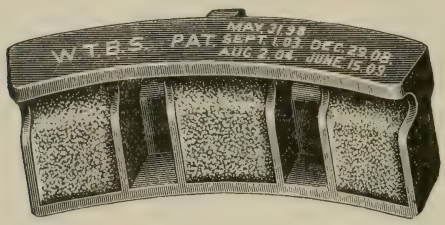
iron so commonly used in service. The wearing qualities of this combination of materials have repeatedly been shown by service tests made on many railroads, while recent laboratory tests have established the claims made for the frictional qualities of these shoes. It is claimed that one of these shoes such as shown in Fig. 15, will outwear six plain cast iron shoes of ordinary hardness.

THE WHEEL TRUING BRAKE SHOE

"Wheel Truing" brake shoes are in reality wheel grinders, made in the form of brake shoes, and used as such while doing the work of truing up car wheels and locomotive driver wheels.

They are interchangeable with the regular brake shoes.

When a wheel needs grinding it is simply necessary to remove the regular brake shoes, apply the truing shoes, run



the car or engine as usual, and when the wheels are found to be in good shape, the truing shoes are removed and held in reserve for another occasion.

The truing shoes are made to fit any brake head, any sized wheel, and the abrasive material is put in the shoes to correspond to that part of the wheel which needs grinding, and where grinding is not required, the material in the shoes is non-abrasive.

FLEXIBLE METALLIC JOINTS.

It has long been customary to convey steam and air by rubber hose when flexibility of construction has been required. In regard thereto it should also be stated that such hose has been perfected in quality to a very great extent. However, the combined effects of the pressure within and the weather without ultimately require its renewal, and the length of time during which it may safely be used is very indeterminate.

With the advent of the air brake on all classes of trains, and steam heating on passenger trains, came a demand for some flexible metallic joint or coupling to be used between the vehicles.

While the air brake train-pipe has normally a greater pressure than the train steam heating pipe, the latter is not only larger but is frequently subject to undue pressures, sometimes approaching the full boiler pressure carried on the locomotive; this might be caused from improperly closing valves near the head end of the train, or more usually from defective pressure regulators on the locomotive. Then, too, more danger and delay are attendant upon the bursting of a steam hose than that of an air hose.

Considerable difficulty has been experienced in designing a satisfactory flexible coupling for all purposes, that should of necessity be easy of coupling and uncoupling. Inasmuch as the locomotive and tender require to be less frequently disconnected than

other parts of the train, it is but natural that a satisfactory metallic connection between these should have first been put into extensive practice.

Although a large number of such devices have been used locally on various railways, it will be the intention to here describe only those which have been used extensively in all parts of the country.

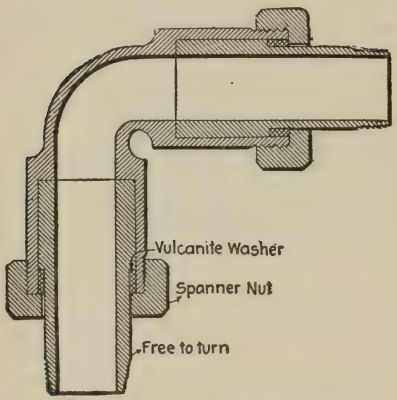


FIG. 1. Section of Swivel Joint.

McLAUGHLIN'S FLEXIBLE METALLIC CONDUIT.

For conveying steam or air between locomotive and tender.

The joints in the pipe are made by swiveling elbows. A nipple, with an enlarged end, is inserted in the bore of the elbow, and is free to turn therein, but is held in place by a cup nut, against which the shoulder, or enlargement of the elbow, bears. A ring of vulcanized rubber is inserted between these surfaces to make a tight joint and to provide for taking up wear.

While adapted to and used for a large number of purposes requiring flexible connections, the most severe test has been made in connecting locomo-

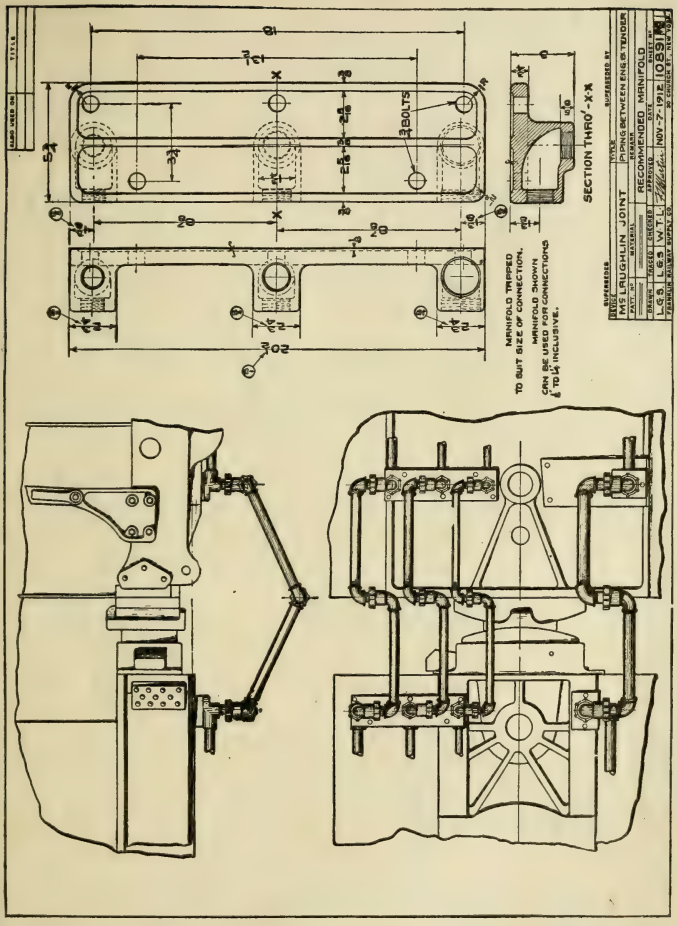

3 BOLTS
SECTION THRO'-X-X
MANIFOLD TRIMMED TO SUIT BEST CONNECTION.
MANIFOLD SHOWN CAN BE USED FOR CONNECTIONS ¾ TO 1¼ INCLUSIVE.
McLAUGHLIN JOINT
PIPING BETWEEN ENG & TENDER
RECOMMENDED MANIFOLD
NOV 7 1911

Fig. 2—McLaughlin Joint, Showing its use on three air and one steam connection between Engine and Tender

tives and tenders for steam heating. In this exacting service the arrangement has given excellent satisfaction for a number of years. It wears well and does not leak. The construction is shown in the engravings.

Any couplings used by any railroad can be used with the joint the same as if it were hose.

This conduit has been adopted by a number of the large railway systems of the country, for all connections of steam and air between engine and tender; also for roundhouse blower connections and oil burners.

CLIMAX FLEXIBLE METALLIC JOINT

Fig. 1 shows the general construction and arrangement with a pet cock at the lowest point of

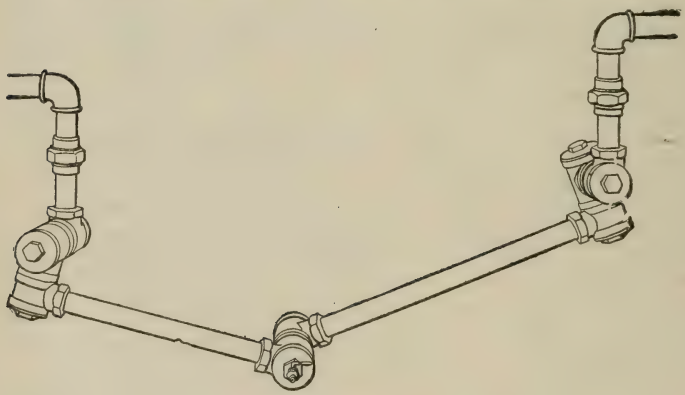


FIG. 1.
Climax Flexible Metallic Joint.

the coupling for drainage of all water when not in use. There is a double or universal joint at each side and a single or swivel joint in the center.

Fig. 2 shows a sectional view of one of the universal joints. They are made entirely of steam metal, and the two glands (*G-G*) are each surrounded by three Jenkins discs screwed down to a joint by the nuts (*E-E*). These nuts have holes

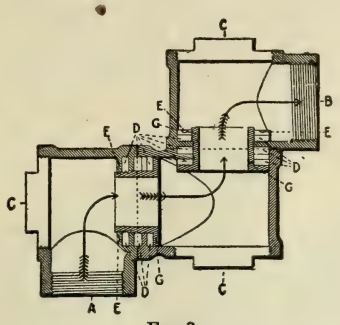


FIG. 2.
Climax Flexible Metallic Joint—Double Joint.

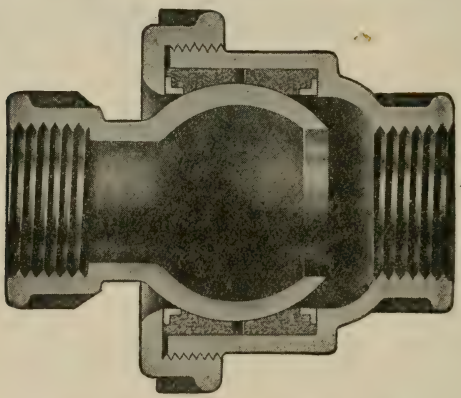
in their faces to permit their removal whenever the discs require renewal. To do this the caps (*C-C*) may be taken off.

The center swivel joint shown in Fig. 1 has a single gland and set of packing similar to those shown in Fig. 2.

BARCO FLEXIBLE JOINTS

These joints are used in connection with iron pipe and fittings to take the place of rubber hose for steam, air, oil and water connections between engine and tender and on the rear of the tender. The flexible joints have a sufficient range of movement to meet every motion of the engine and tender and accommodate themselves to the sharpest curves and cross-overs which the engine is capable of taking.

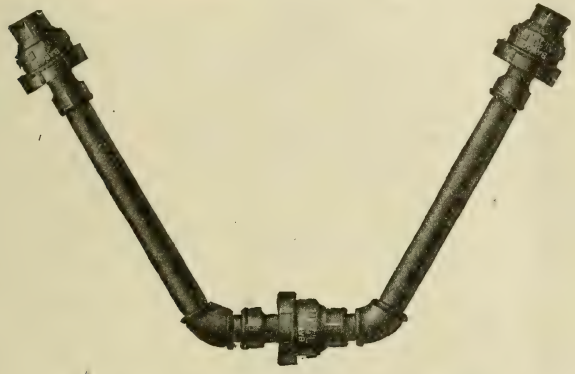
By reference to the sectional illustration, it will be seen that each joint consists of a ball, with an outlet threaded



Barco Flexible Joint—Sectional View

for iron pipe, and two non-metallic gaskets surrounding the ball, which are held in a metal casing by a threaded cap. These gaskets provide a somewhat resilient seat for the ball and always conform to the surface of the ball, making the joint absolutely tight under all conditions. The ball is free from grinding, which would result if it were seated on a metal surface, and the fact that it has an upper and lower seat makes the joint doubly serviceable and tight. The joint is entirely free from springs, soft packing and adjustable features and is, therefore, well designed to stand the hard service required for the present locomotives.

The second cut shows an engine tender connections, one end of which is attached to the pipe on the engine and the other is attached to the pipe on the tender. These connections are usually provided for steam line (1½″ or 2″ pipe), main air-brake line (1¼″ pipe), signal line (¾″ pipe), independent brake line (¾″ pipe) and sometimes on oil line (¾″ to 1½″). In using these joints on the rear of the tender, two joints are used, with a nipple of proper length between them, and a standard coupling attached, to match that on the hose, and are hung in the same way and connected up by means of a standard coupling in the usual manner.



Barco Flexible Joint—Complete Coupling

The use of these joints in connection with iron pipe for blower line connections, blow-off connections and washout nozzles in roundhouses is quite general and the desirability of metallic connections for these purposes is obvious; also it has frequently been found desirable to use these joints on main reservoir piping where the excessive vibration is apt to break off the nipple, or in connection with other piping, such as a steam pipe on a turbine headlight where there is a good deal of vibration and consequent likelihood of breakage. The joints in these cases allow a freer movement of the pipe and take up the shock.

PRESSURE GAUGES.

The first devices for indicating the varying changes of pressure were extremely crude, although the absolute standard is and always has been the weight of mercury (quicksilver) expressed in pounds pressure per square inch.

One of the first pressure gauges used was a simple "U"-shaped glass tube partly filled with mercury; the pressure admitted to one side lowering the level in that side and raising it in the other. The difference between the two levels determined the pressure—2 1-32 inches (approximately) being equal to one pound per square inch at a temperature of 60 degrees Fahr.

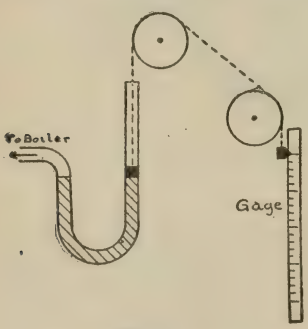


FIG. A.
Mercury Column and Gauge.

When it was not convenient to graduate directly upon the glass tube, recourse was had to a metal tube with a float and independent scale in some convenient location. The engraving Fig. A shows such a U-shaped tube with float transferring the indications to a scale by means of a cord over pulleys.

While the mercury gauge has been greatly perfected it is, as before stated, still the standard gauge to this day. The most accurate test is a perpendicular iron tube, immersed in a sealed pot of mercury at its

base and running high in the air (see Fig. 1). The pressure from the test pump is applied to the surface of

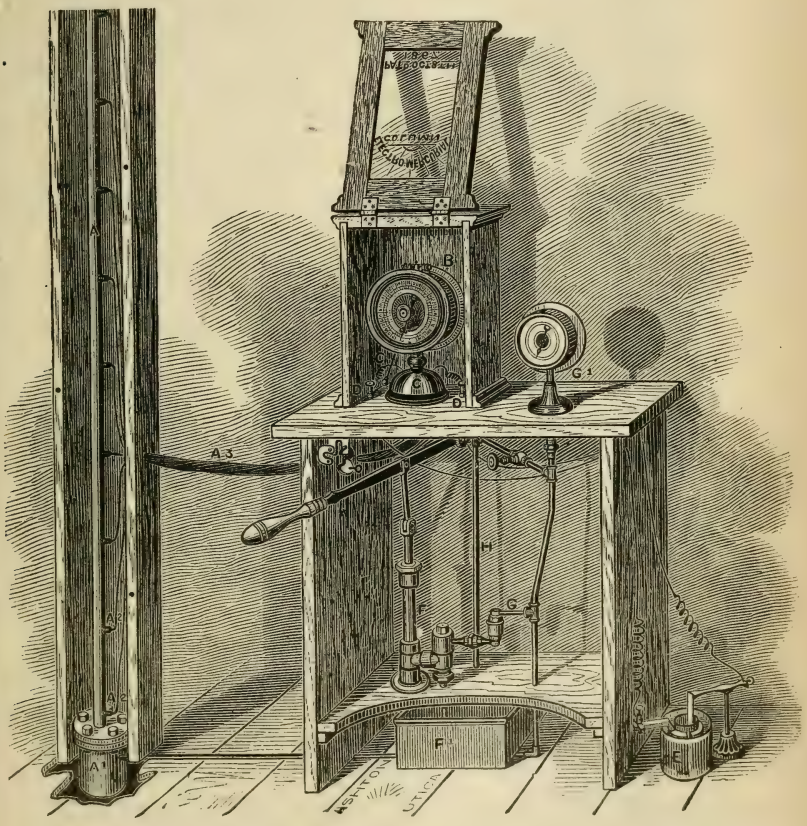


Fig. 1.
Electro-Mercurial Gauge Tester.

the mercury and causes the latter to rise in the tube to a height proportionate to the pressure applied. At

each point of graduation on the tube, an insulated platinum wire point is inserted and connected with an electrical register. By means of battery connections to the mercury and to each platinum point, when the two come in contact at each graduation, the electrical register is formed.

Although the sealed tube was allowed on higher pressures, yet as late as 1843 the French government required the open tube to be used for engines under sixty pounds and steamboats under thirty pounds pressure per square inch.

On account of its defects and disadvantages for ordinary pressure measurement, the tube of mercury gradually gave way to gauges of mechanical construction, more suitable for practical use. The designs and modifications of such mechanical gauges are now quite numerous, but for years there were two principal types, viz.: the "Bourdon" tube and the "diaphragm."

The single spring Bourdon gauge as shown in Fig. 2, is dependent for its action upon the fact that pressure admitted to a bent tube has a tendency to straighten it; however, it was found to be open to objection from two main causes--(1) The end of the tube, after passing the top center, became a pocket for water of condensation, and hence became liable to damage by frost. (2) As the tube was long and sensitive to motion, it was found not

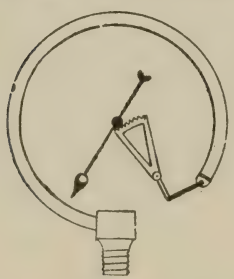


FIG. 2.
Single Bourdon Spring Gauge.

accurate on a locomotive or any moving machinery, as the jolt and jar kept the pointer in such a constant vibration as to prevent a correct reading of the pressure being obtained.

Each improvement upon this single Bourdon tube gauge consisted mainly in cutting off a piece of the tube, until finally the tube did not pass the top center. The vibration and pocket features were thus overcome, but at a sacrifice of the motion of the spring. This finally resulted in the introduction of the double

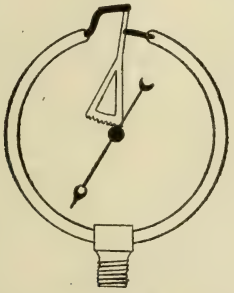


FIG. 3.
Double Bourdon Spring Gauge.

Bourdon tube gauge, which is shown in Fig. 3. This was found to be more satisfactory and free from the two former prime objections to the Bourdon tube. The principle of this double Bourdon tube is the same as of the single tube style, and this principle can readily be understood by noticing the tendency of a coil of hose to straighten out when pressure is admitted within it.

The other type referred to is the diaphragm gauge, invented in about the year 1849. One of the earlier

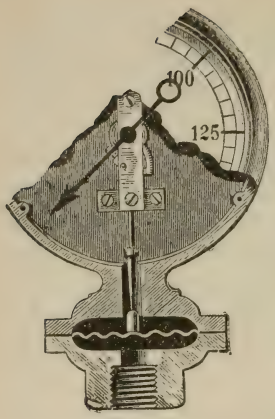


FIG. 4.
Early Form of Diaphragm Gauge.

forms of this gauge is shown in Fig. 4, having the diaphragm located in a compartment below the gauge. The objection to this gauge, as originally designed, was in the use of the flat diaphragm fastened rigidly at the circumference. It was impossible to make allowance for the drawing in toward the center when pressure was applied. The diaphragm made of a corrugated plate has finally been used to reduce this tendency.

Fig. 5 clearly illustrates another and different form of diaphragm gauge. In this gauge there were several corrugations on one side and none on the other; the pointer was fastened perpendicularly, as shown, at the center of the diaphragm. Thus the extra movement on the corrugated side, produced by the applied pressure, moved the pointer or hand of this gauge along the graduations.

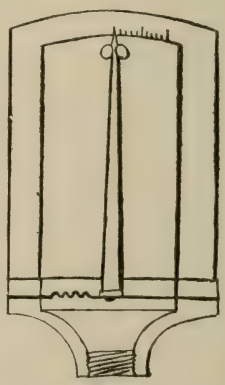


FIG. 5.
Early Form of Diaphragm Gauge.

Siphons and Siphon Cocks.—Wherever a pressure gauge is to be used for steam, siphons are indispensable.

For very small gauges bulb siphons or "traps," three styles of which are shown in

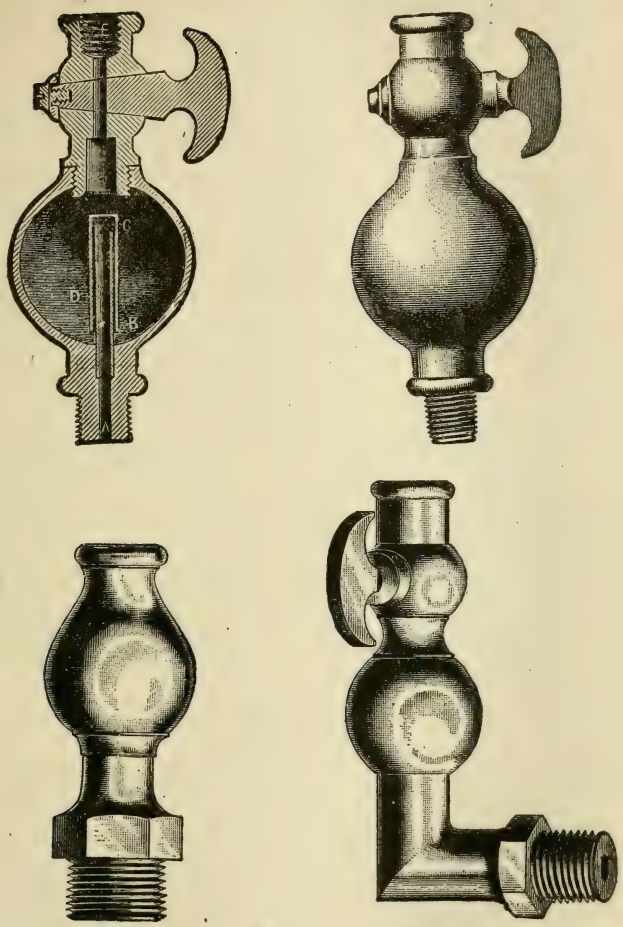


FIG. 6.
Bulb Siphons or Traps.

Fig. 6, are often used, but for larger gauges a pipe siphon, as illustrated in Fig. 7, is used, as it can be made of such size as necessary to hold sufficient water.

FIG. 7. Coil Pipe Siphon.

It should be particularly understood by those using pressure gauges of the types hereinafter shown that none of the manufacturers warrant these gauges for steam use unless a siphon is attached that will supply sufficient water to fill the tubes and springs, otherwise they become heated by steam and cannot be depended upon for accurate indications of pressure.

The principle of the siphon is readily understood by reference to steam heating pipes in any house, or in the pits of a roundhouse, with which all are familiar. It is well known that pipes gradually sloping will permit steam to pass throughout their length, but that when there is a low place anywhere the water will settle at that point and remain unless there is an outlet beyond through which the steam pressure behind can force the water. These siphon pipes are used to form such traps for steam gauges, and it should be borne in mind that any leak, no matter how slight, between the siphon and gauge, will permit the steam to force the water out and itself enter the gauge.

All gauges used on a locomotive, whether to indicate steam or air pressures, should be placed as far from the boiler as possible, and, while rigidly secured to prevent vibration, they should be mounted on brackets insulated as well as may be from the heat radiating from the boiler or by conduction through the bracket. To minimize this conducted heat,

gauges should preferably be fastened to wooden blocks, and the latter to the boiler gauge bracket itself.

CROSBY LOCOMOTIVE PRESSURE GAUGE.

This gauge has the double Bourdon tube springs, as shown in the engraving, Fig. 9. The tube springs are connected at each end with their respective parts by screw threads without the use of any soldering material whatever, thus insuring tight joints under extreme conditions of heat and pressure. The lever

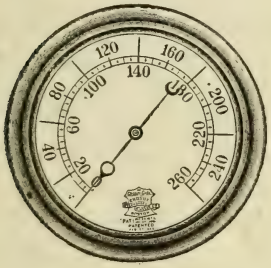


FIG. 8.

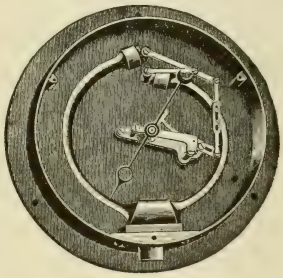


FIG. 9.

Crosby Locomotive Pressure Gauge.

mechanism, which transmits the free movements of these Bourdon tube springs to the index, has been designed with great care, and so that it may be easily renewed in case of repairs.

These gauges for locomotive use are graduated to any pressure not exceeding five hundred pounds per square inch.

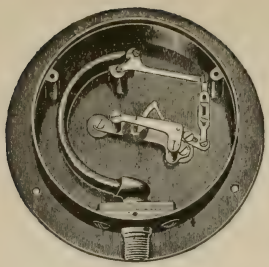


FIG. 10.
Crosby Single Tube Gauge.

Fig. 10 shows the internal arrangement of a single Bourdon tube spring Crosby gauge. This gauge is designed to meet the demand for a cheaper gauge than the more accurate double tube form before illustrated.

The thermostatic water back gauge shown with single and double Bourdon tube springs in Figs. 11 and 12, is particularly adapted for use on high-pressure locomotives, especially compound locomotives, which frequently carry a boiler pressure of two hundred pounds, or over.

It is well known that when a steam gauge in use, on account of its location, is heated to a temperature of 100° Fahr., and upwards, that there is an expansion of its parts, due to the heat, to such an extent that it will be erroneous in measuring the pressure which it should record. In such cases the parts which materially affect the correct operation of the gauge are the tube springs. It occurs thus: The tube springs having been tested and adjusted to a certain movement under pressure in the ordinary temperature of the factory, or where it takes place, will when the same are heated in use to a high temperature lengthen by expansion to such an extent that, when they are subjected to the same pressure, their free ends will move through a larger arc than when they were tested. This movement multiplied by the ordinary mechanism of a steam gauge for transmitting it, causes this increased pressure to appear upon the dial. In such

a heated condition of the tube springs, the error produced is sometimes considerable, being several per cent. greater than the true pressure, thus deceiving the user of steam into the belief that he is getting a less result, in work, from the indicated pressure than he ought. This error can be corrected by suitable mechanism in the steam gauge. Such an one, it is claimed, is internally shown by Figs. 11 and 12. In the ordinary steam gauge, the bar which transmits the movement of the free ends of its tube springs is

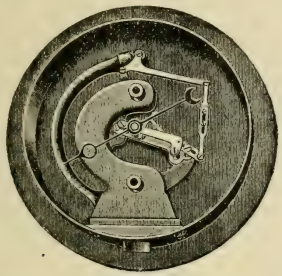


FIG. 11.
Single Bourdon Tube Spring.

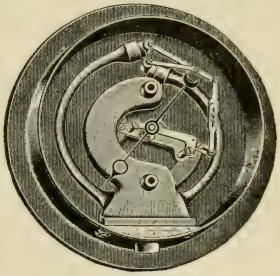


FIG. 12.
Double Bourdon Tube Springs.

Crosby Thermostatic Water-Back Gauges.

made of a homogeneous metal, and when the tube springs are affected under heat as above stated, it transmits the increased movement just in the same way that it would transmit the intended or designed movement when the tube springs are cold. Thus the error arises. In the improved gauge above shown, this bar is made of brass and steel brazed together, forming a thermal bar, so that, under the influence of high temperatures, it will compensate for the expansion or lengthening of the tube springs and their greater movement thereby under pressure, by retarding

simultaneously the motion of the index which records such movement on the dial. The action of this thermal bar is, that its end remote from that where it is attached to the tube springs will droop, or deflect, or move oppositely to the tube springs on account of the action of the temperature upon the two metals composing it, as is commonly understood. This opposite movement retards the index proportionately to the lengthening of the tube springs, as they are both influenced by the same temperature, and thus compels it to keep back to the notation of pressure on the dial where it correctly should be.

In addition to this thermal bar, this gauge has a chamber, so constructed that when filled with water or other liquid it not only supplies the Bourdon tube springs, connected to it with all that is required, but serves to equalize the temperature about them. This is important. For unless the tube springs are subjected to a heat greater than 212° Fahr., they do not set when in use; and as it is impossible, as made, under ordinary conditions of use, for heat to be transmitted by conduction to such an extent, they are secure from this danger.

This chamber is located in the gauge case so that it has its connection to it and with the boiler at the bottom. Attached to it are the tube springs, the index mechanism, and the dial, the latter upon the bosses; and all are independent of the case and are free from any influence of it under heat, excepting at its immediate point of attachment, which is unimportant.

The chamber of this gauge is filled with a liquid which is not seriously affected by exposure to cold, nor is it injurious to the operation of the gauge. Upon

the removal of the cork which is inserted in the inlet of the gauge connection to prevent leakage during transportation, it may be attached to the boiler in the usual manner without a siphon or other device for furnishing water to it.

Should it become necessary again to fill the chamber with water or other liquid, remove the small screw located in the case by the side of the gauge connection, to provide a free course from the inlet in the gauge connection, around through the chamber and tube springs to the open air. Then, holding the gauge so that the inlet will be uppermost, pour the liquid used into it, occasionally shaking and turning it to expel the air and assist the flow of the liquid into all parts of the chamber and tube springs. When they have received about two fluid ounces of the liquid, and it appears at the aperture of the screw removed, they will then be filled. Close this aperture tightly with the screw and the gauge will be ready for use.

THE LANE PRESSURE GAUGE.

This gauge is shown by Fig. 13. The improvement in this gauge consists of a bent lever provided with an adjustable link at its head, to which one of the tube springs is attached, the other tube spring being directly connected with this lever. By this plan the movements of the lever and rack, relatively to the two tube springs, can be more readily and perfectly adjusted than by any other method in use in this style of gauge.

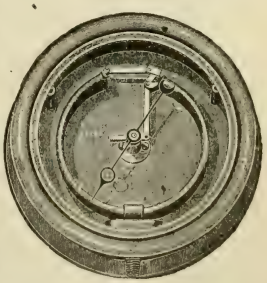


FIG. 13.
Lane Pressure Gauge.

STAR GAUGES.

In designing a spring tube that will not retain any permanent set after repeated bending back and forth with varying pressure, the manufacturers of this gauge make use of a corrugated tube, as shown in the accompanying engraving. These makers also lay special stress upon the point that they have for many years manufactured a non-corrosive movement in their gauges, thus avoiding the injurious results of smoke and gases.

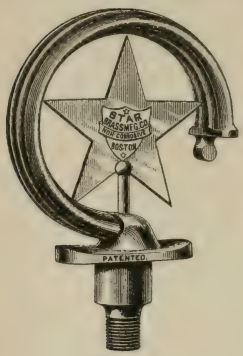


FIG. 13-A.
Star Corrugated Spring.

STAR NON-CORROSIVE AND NON-SETTING LOCOMOTIVE STEAM GAUGES.

Two styles of these gauges are illustrated by Figs. 14 and 15. The former (the standard) known as the double spring Bourdon type and Fig. 15 shows the double spring Lane type.

Each style of gauge is fitted with their non-corrosive movement and corrugated spring tubes.

It is a well known fact that in all branches of mechanical engineering where lightness, rigidity and

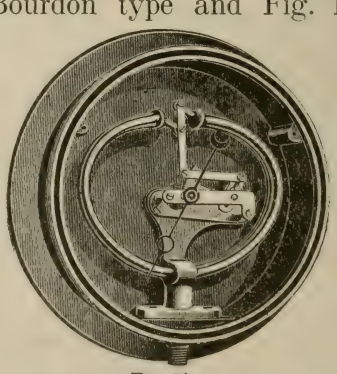


FIG. 14.
Star Double-Spring Gauge—Bourdon Style.

strength are required, corrugation is adopted where practicable, in order to give the necessary stiffness without increasing the weight. Hence it is claimed that the corrugated spring tube is superior to the plain forms. These gauges are fitted with hair springs to take up all lost motion, after the approved practice of all accurate pressure gauges.

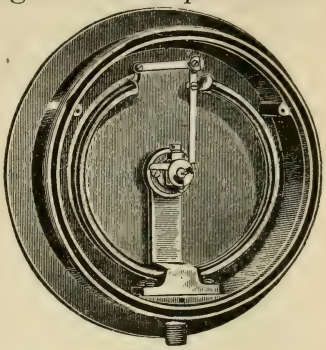


FIG. 15.
Star Double-Spring Gauge—Lane Style.

THE ASHCROFT GAUGES.

These gauges have non-corrosive movements and are constructed of Bourdon springs of seamless drawn tubing.

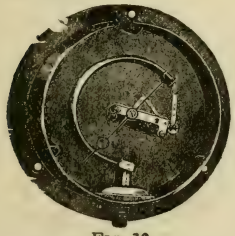


FIG. 16.
Ashcroft Single Bourdon-Spring Steam Gauge.

Fig. 16 shows the interior mechanism of the single Bourdon spring steam gauge, and Fig. 17 the same of the double Bourdon spring gauge with the addition of the Lane improvement in attachment of springs to movement as referred to hereinbefore.

FIG. 17.
Ashcroft Double Bourdon-Spring Steam Gauge, with Lane's Improvement.

In order to provide a gauge that should be accurate, durable and exempt from the annoyance of permanent set of the Bourdon

springs, these manufacturers provide a locomotive steam gauge having an auxiliary spring, as shown in Fig. 18. The auxiliary spring feature consists of an independent co-operating spiral spring (*A*) applied to the free end of the single Bourdon tube, which dispenses with the necessity of a second tube, and reduces the number of joints subjected to wear and friction between the tube and the segment of the recording movement to two. The Bourdon tube, it should be noticed, is short enough to drain itself and thus prevent damage by freezing.

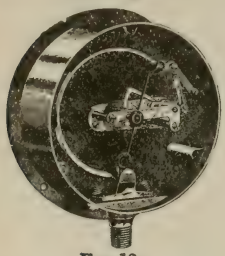


FIG. 18.
Ashcroft Auxiliary Spring Locomotive Steam Gauge.

Figs. 19 and 20 illustrate the Ashcroft double spring standard locomotive gauge, the internal arrangement being clearly shown.

FIG. 19.

FIG. 20.
Ashcroft Double-Spring Standard Locomotive Gauge.

THE UTICA GAUGE.

In construction, this gauge differs from those previously described chiefly in its spring, which is, of course, the essential part of any gauge, as all movements of good gauges are constructed with great care.

The "capsular" spring is the style of spring employed

and is made in two sizes for large and small gauges, as shown in Figs. 21 and 22. It consists of a spring

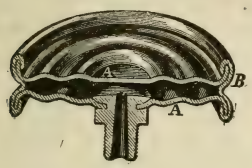


FIG. 21.
Utica Capsular Spring.

FIG. 22.
Utica Capsular Spring.

box, capsular in form, with the circumferences of the two heads (*A A*) flanged and locked together (in the larger form) in an elastic band (*B*) at a point above and below the spring heads themselves. This fastening thus acts as a hinge joint. It should be noticed that this Utica spring has two heads, while the old style diaphragm spring, as described in the introductory remarks on gauges, has but one. Thus, the former gives double the motion for the same movement of the spring. Inasmuch as the manufacturers agree to replace any steam gauge which shows a cracked spring-head, it need scarcely be said that great care is taken in the selection of metal and in the making of these springs.

Fig. 23 shows a Utica locomotive steamgaugepartially sectioned in order to illustrate its internal

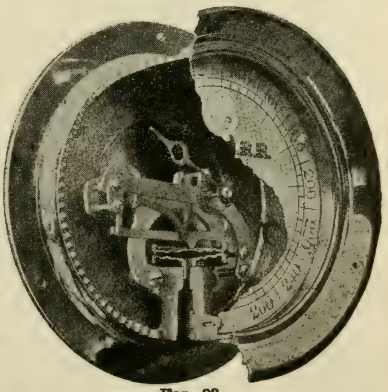


FIG. 23.
Utica Locomotive Steam Gauge.

mechanism. A bell crank bears against the top of the upper spring head. The pressure within the spring causes the heads to bulge and bear against this crank, which is joined by means of light lever connections with the pointer, thus indicating the pressure.

THE DUPLEX AIR BRAKE GAUGE.

The Air Brake Gauge is an essential part of the automatic brake system. It records two pressures, namely, that in the main reservoir and that in the train line. It will be noted that the hands indicating these pressures are of different colors, that for the reservoir pressure being red and that for the train line pressure black. The difference between these two pressures is the excess pressure in the reservoir over that in the train line, and it is important that this excess should always be at least twenty or twenty-five pounds. The location of the air gauge on the locomotive is shown in the plate "The American Type Locomotive," part numbered 207.*

The duplex air brake gauge is usually so designed and constructed that each spring, while acting entirely independent, registers its movement through its own index hand upon the same circle of figures. These air brake gauges are subject to such wide and rapid variations that their construction must be of the very best.

*The Air Gauge is described and illustrated in "The Science of Railways," in connection with the exposition therein of the Air Brake, and the reader is referred to the volume devoted to that subject for reference to further information on the subject.

The standard "Westinghouse" type of duplex air gauge, as manufactured by the Ashcroft Manufacturing Company, is shown in Figs. 24 and 25. From the

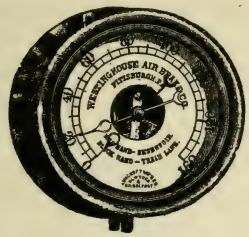


FIG. 24.

FIG. 25.
Sectional View.

Westinghouse Duplex Air Gauge.

latter figure it will be seen that each pointer or gauge hand is acted upon independently of the other pointer by double Bourdon tube springs.

A later style of duplex air gauge, called the "Sema-

FIG. 26.

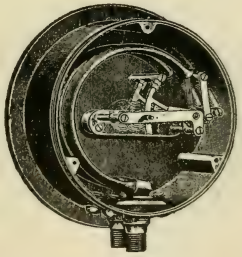


FIG. 27.
Sectional View.

Semaphore Duplex Air Gauge.

phore" gauge, is shown in Figs. 26 and 27. The points of difference in this gauge are the use of single Bourdon springs with auxiliary springs (as described

more fully under Steam Gauges) and the black dial with white figures so arranged that their positions for the three pressures, fifty, seventy and ninety pounds per square inch (the most important pressures to the engineer for operating the air brake) enable him to instantly and accurately observe the variations of pressures in his air brake system; for the two extreme pressures of fifty and ninety always stand at right angles with the seventy pounds pressure point which is at the top of the dial. On this dial a much wider space is allowed for each five pounds pressure, so as to insure closer and more accurate reductions in train braking. The glass over the dial is an oval crystal like a watch, and while the case does not extend in front of the glass as usual to afford protection from breakage, yet this arrangement enables the engineer to read the gauge when it stands at a considerable angle to him.

FIG. 28.

FIG. 29.

Crosby Duplex Air Gauge.

The interior mechanism of the Crosby duplex air gauge is clearly shown in Figs. 28 and 29. These cuts show the double attachments of this gauge so

located that in Fig. 28 the two pressures are connected to the gauge nipples, one before the other, in a line with the center of the gauge, while in Fig. 29 these connections are one at each side of the center of the gauge. The words "train line" or "reservoir" are stamped on the gauge nipples so that they can be distinguished in connecting pipes to the gauges.

The dial of this gauge is the same as that shown in Fig. 24.

The Star duplex air gauge differs from the gauges last described mainly in the use of corrugated Bourdon springs, as shown in Fig. 13-A.

A very useful gauge for assistance to Air Brake Inspectors or others testing the air pressure carried by a locomotive, is shown in Fig. 30.

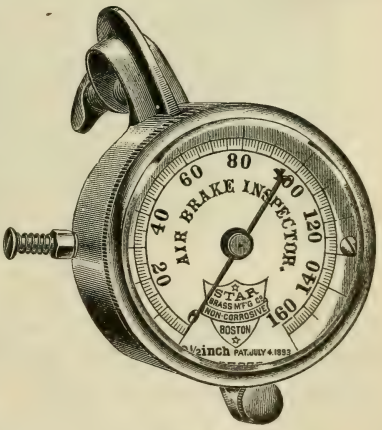


FIG. 30.
Star Air Brake Inspectors' Gauge.

By means of the adjustable thumb screw at the bottom this gauge may be applied to either the train line or air signal hose on the rear of an engine or train.

The exception above noted to the usual form of dial where both hands indicate their pressures from the same figures is the Utica form of duplex air gauge, as shown in Figs. 31 and 32.

FIG. 31.
Utica Duplex Air Gauge.

It is virtually two gauges in one, as but half of the dial is used for train-line pressure and the other half for main reservoir pressure.

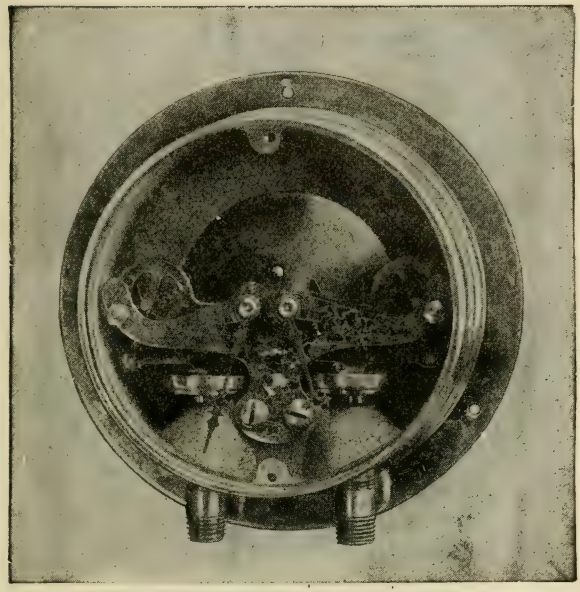
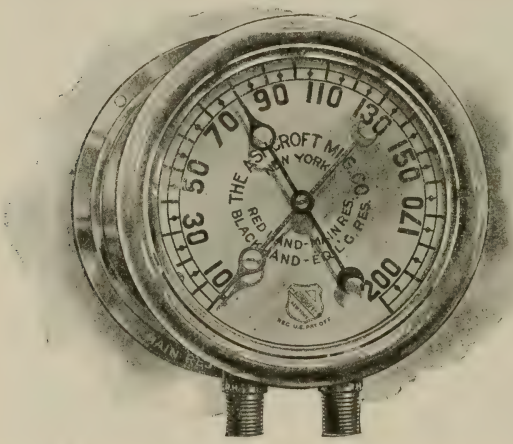


FIG. 32.
Utica Duplex Air Gauge.

The interior of this gauge may be seen from Fig. 32 to consist of two "capsular" springs, each actuating its own pointer.

ASHCROFT HYDRAULIC GAUGE

The interior mechanism consists of a single steel spring and standard geared movement. The connection is a one-half-inch male bottom with wrench space for use in connecting the gauge and contains a check valve to eliminate shock due to the sudden release of pressure. This gauge may be graduated to any pressure from 1,000 to 20,000 pounds. The equivalent in tons on a given size ram may be graduated on the same dial if desired. A maximum hand, operating on a separate scale in the center of dial and showing the maximum



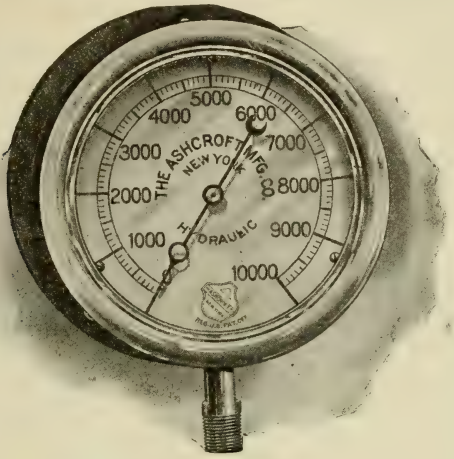
Duplex Air Pressure Gauge

pressure to which the scale has been subjected is also furnished when required.

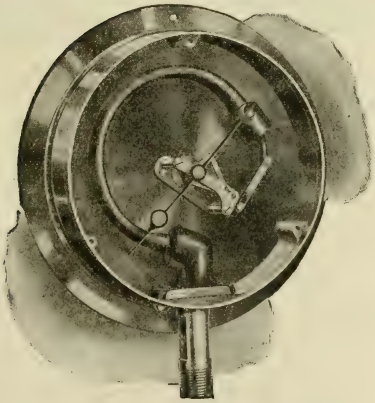
ASHCROFT DUPLEX PRESSURE GAUGE

This is a pressure gauge which indicates two separate pressures on a single dial and scale and is for use on the air-brake system. The interior mechanism consists of two springs and standard geared movements acting independently

of each other. One movement is supplied with a red hand and the other with a black hand. The connections are ¼-



Hydraulic Valve



Interior—Hydrostatic Gauge

inch male bottom, placed side by side. These gauges are graduated to any pressure required, from 100 to 500 pounds.

PRESSURE RECORDING GAUGES.

In order to have a graphic record showing every variation of pressure and the time of day or night, the pressure recording gauge is sometimes applied to a locomotive. While it is usually used to record the steam pressure, the more recent introduction of the recorder for the air brake train-line pressure is liable to institute a greater use for this latter purpose.

FIG. 33.
Pressure Recording Gauge

FIG. 34.
Star Pressure Recording Gauge.

Both the Crosby and the Star pressure recording gauges are similar in appearance, hence Fig. 33 will indicate the external appearance of either one. Fig. 34 shows a Star recording gauge that has an ordinary gauge dial and pointer outside of the recording disc. In all these gauges, by the aid of suitable mechanism, not shown, the pressure which is to be recorded is brought to bear upon the lever (seen on the left hand side of the cut) in such a way as to move it away from or toward the center, according as the pressure is increased or reduced in the boiler or train brake pipe.

At the end of this lever is carried a pen charged with

red ink, and the point of this pen rests lightly upon the paper chart which has curved radial lines coinciding with the pressure movements of the point of the pen, were the paper chart itself held stationary. The circular lines on the chart serve as graduations to mark the degree of pressure, and are numbered by four columns of figures. The paper charts shown in Figs. 33 and 34 are designed to be rotated once every twenty-four hours by a clock movement of great accuracy.

Thus it will be seen that with the chart steadily rotating any variation of pressure will cause the pen to move across the line of movement of the chart, producing a more or less zig-zag red line, and thus recording accurately the pressure at the exact time of day or night that it occurred.

The chart must be set right according to the time of day before the thumb screw in the center is tightened. The reading of the two charts here shown in Figs. 33 and 34 is the same and would be 110 pounds pressure at 6:30 o'clock A. M.

The Crosby Air Brake Recording Gauge is of the same construction and has the same appearance as that used for steam, as shown in Fig. 33, except that it is graduated for five pounds to each circular line and the highest pressure shown is ninety pounds.

It is well known that in the use and operation of air brakes there exist certain negative conditions, which, as a whole, tend to reduce their efficiency, and are thereby opposed to safety and economy. Very great importance, we believe, is attached to carrying a standard pressure—no more nor less—at all times; that the brakes are in perfect working order; and,

above all, that proper discretion is exercised in their manipulation, otherwise the power of the brakes is either over or under developed. The former is conducive to delay, waste of fuel, overheating and cracking of wheels and wheel flattening; the latter to loss of control, from which arises the gravest and most serious of possibilities—that of accident. That it is important and desirable that these conditions should be overcome, every one, we think, will admit; but that it may be done, it is first necessary to know where and how they exist. This information may be obtained by using an air brake recording gauge, an instrument designed for continuously recording the pressure of air used in the operation of air brakes.

In using these recording gauges for indicating steam pressure the same care, as heretofore explained, should be exercised to prevent live steam from entering and heating the gauge.

GAUGE HAND OR "POINTER" PULLERS.

Three styles of hand or pointer pullers are shown in Figs. 35, 36 and 37, either one of which is a very

FIG. 35. FIG. 36.
Gauge Hand or "Pointer" Pullers.

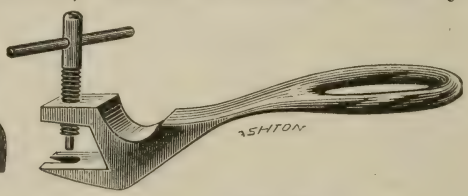


FIG. 37.
Gauge Hand or "Pointer" Pullers.

handy tool for use in removing gauge hands with the least liability of damage to either the gauge, movement, or the hands themselves.

TESTING GAUGES.

Engineers and firemen depend almost entirely upon the steam and air gauges to know the pressure under which the locomotive in their charge is working, and yet they are fully aware that these gauges do many times get out of order. Knowing full well that the locomotive is not pulling what it should, they report the gauge out of order. When the engine arrives at the terminus, the practice too frequently is to remove the gauge from the engine, take it to the shops and have it tested, that is, tried in comparison with an accurate gauge, known to be correct, which gauge is called a test gauge.

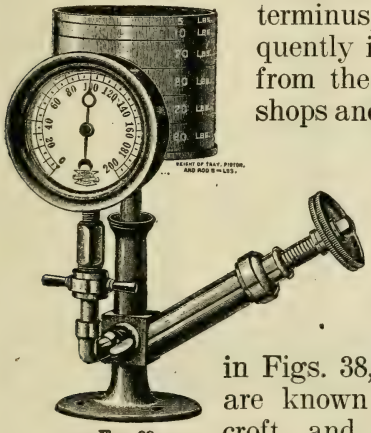


FIG. 38.
Crosby Test Gauge.

Three of such testing devices are shown in Figs. 38, 39, 40 and 41, which are known as the Crosby, Ashcroft, and Star, respectively, and will be described hereafter.

There is no question but that this test will determine if the gauge itself is defective at the time and under the existing temperature of the testing room, but it does not by any means follow that this same gauge will correctly indicate the pressure when placed in the cab of a locomotive. At the beginning of this chapter the instructions regarding proper piping, insulation and location of gauges were called to the attention of the

reader, but these precautions are not always observed even by designers and builders who make the finest locomotives and equip them with the most modern devices.

It is possible, owing to the location of a gauge, to have it in error from one to twenty pounds (and even more, in extreme cases) and yet have the gauge

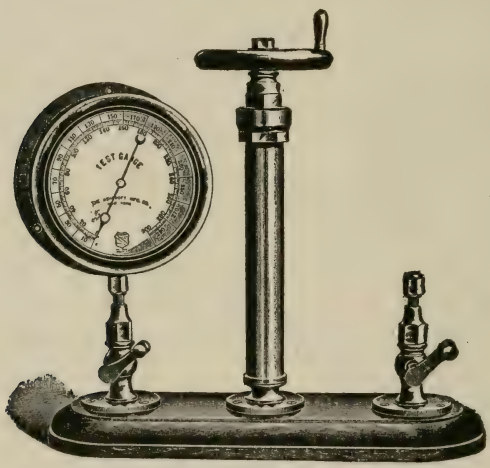


FIG. 39.
Ashcroft Test Gauge.

show correct every time it is removed and tested. All gauges are adjusted cold and the fine mechanism therein will correctly indicate pressures when all parts are at this moderate temperature. Almost all metals weaken as their temperature becomes higher. Hence the springs in the gauges will have a greater deflection than normal when heated above a moderate temperature, and will thus indicate a greater pressure

than that actually existing in the boiler or other receptacle to which they are attached.

For the reasons hereinbefore given, it is strongly advocated by those with extended experience in such matters that it is much better to allow the gauge to be tested to remain upon the locomotive, in its usual location. If the steam gauge is to be verified, attach an accurate test gauge with a large siphon pipe (as shown in Fig. 7) to some convenient connection at the steam dome and compare the

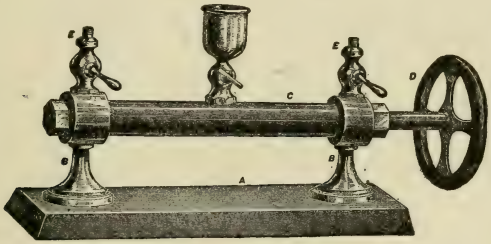


FIG. 40.
Star Test Gauge.

readings of this test gauge with that of the gauge in the locomotive cab, manipulating the fire and injectors sufficiently to cause the pressure to pass through the ordinary variations that exist in service. Incidentally, there is considerable of an advantage aside from the time it saves and the accuracy thereby secured in not removing the gauge, in that no couplings or connections are disturbed, and hence no leaks produced; for leaks anywhere above the gauge siphon are very injurious to a steam gauge.

To test the air gauge, couple an ordinary gauge which is known to be accurate, or the gauge shown

in Fig. 30, to the train brake hose at the rear of the tender, or some convenient but cool place in the cab; cause the pressure to vary through its usual range, and compare the attached gauge with the one located on the boiler head.

Steam gauges on a locomotive sometimes show less pressure than that actually in the boiler, on account of their being attached to the steam turret or fountain instead of deriving their pressure directly from the boiler itself. This difference can readily be detected by noting a sudden drop or rise in the pressure indicated by the gauge when the injectors, air pump, steam-heat, electric headlight, etc., which take steam from the fountain, are suddenly opened or closed, as the case may be.

The Description of Gauge-Testing Devices here illustrated is as follows:

The Crosby Gauge Tester, shown in Fig. 38, consists of a stand from which rises a cylinder having accurately fitted into it a piston with an area of exactly one-fifth of a square inch. This piston moves freely up and down, and has attached to the top of the piston rod a disc for supporting the weights. Each weight is marked with the number of pounds per square inch it will exert on the gauge. From the bottom of the cylinder two tubes project; one forms a stand for holding the gauge to be tested, the other rises at an inclined angle and forms the oil reservoir having within it a screw plunger for forcing the oil inward or outward. Screw down on the plunger until the weights are lifted, and then note the reading of the gauge as compared with the weights, counting the weight of piston, piston rod and tray equal to five

pounds. The piston should be carefully cleaned of all oil and gum after each test.

The Ashcroft Gauge Tester is shown in Fig. 39, and its operation is very similar to that last described, except that instead of known weights being used a

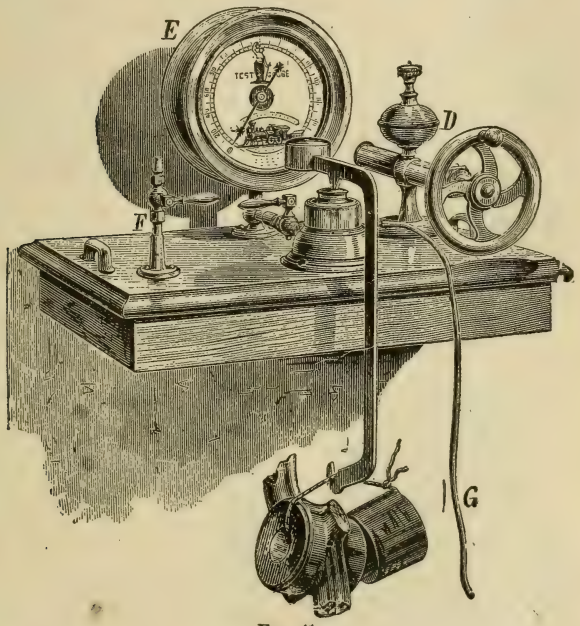


FIG. 41.
Utica Gauge Tester.

test gauge is attached to the nipple to left of the vertical screw plunger, while the gauge to be tested is attached to the nipple on the right. By screwing down the screw-feed the pressure is gradually increased up to the desired limits of the reading of the gauge to be tested.

The Star Gauge Tester, as illustrated in Fig. 40, is used precisely the same as that shown in Fig. 39, but in the cut the test gauge is not shown and the screw plunger is placed horizontally. An accurate test gauge is attached to one of the nipples (*E E*) and the gauge to be tested to the other nipple. Screwing in on the plunger wheel (*D*) increases the pressure of oil to any amount desired.

The Utica Gauge Tester is clearly illustrated by Figs. 41 and 42. The latter engraving shows the square-inch test valve, which consists of a brass disc provided with a pipe (*A*) to be connected with a plunger (*D*), as in Fig. 41. At *B* is a hardened steel valve and seat, the latter having knife edges for the valve (*B*) to rest upon, and being made exactly one square inch in area. The pipe (*A*) opens directly under the valve, as shown by the dotted lines. Fig. 41 is intended to show the use of this square inch valve in connection with an

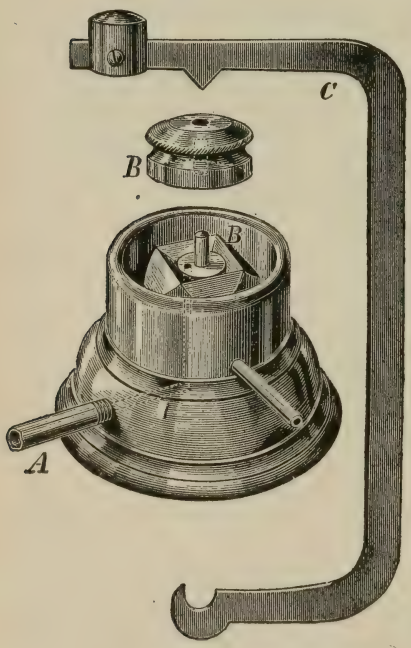
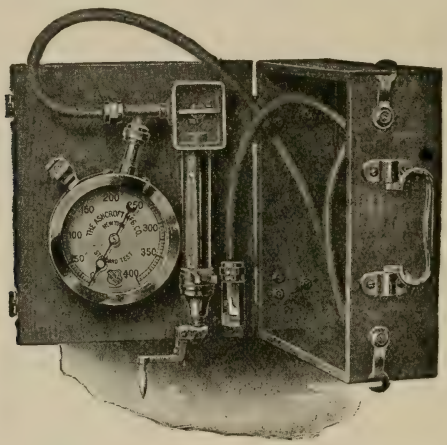


FIG. 42.
The Utica Gauge Tester.

ordinary screw plunger (*D*) and a test gauge at *E*. The gauge to be tested is attached at *F*. The pieces of iron attached to the bottom of the yoke, together with the valve and yoke itself, have been previously weighted, so that the valve must lift and the water escape by the overflow pipe (*G*), the moment such known weight is exceeded by the water pressure. The gauge to be tested should then indicate a pressure per square inch equal to the combined weights of the valve, yoke, and weight attached.

ASHCROFT PORTABLE LOCOMOTIVE GAUGE TESTER

This outfit was designed to test locomotive steam and air gauges without removing them from their location in the engine cab. All parts are very compactly fitted in the portable carrying case and are permanently mounted, except the hose and its connection which are simply removed from their clips to couple to the gauge to be tested. While the test is being made, the case and its contents can be placed in any convenient position in the cab.



Portable Locomotive Gauge Tester

To operate, the piping of the gauge to be tested is disconnected and the hose of the tester filled with water. A convenient way of doing this is to drop the outside end of the hose into water with the piston screwed clear in; by backing out the piston the water will be drawn in, filling the system. The test can now be made, the hose connection being connected to the gauge. The pressure is applied by screwing the piston inward. If sufficient pressure is not generated to test the entire dial of the gauge, the filling chamber should be filled with water, the three-way cock turned to connect the chamber with the pump barrel and the piston again backed out. After turning the three-way cock to the working position the test can be concluded.

LOCOMOTIVE POP SAFETY VALVES.

While there are a great many styles of pop safety valves used on locomotives, only the types especially designed for this use are here described.

The cause of boiler explosions is excessive pressure, and the fact that such disasters are of not infrequent occurrence, whether arising from neglect or otherwise, points forcibly to the necessity of providing against them in every possible way. There are safeguards against the danger of explosion which manufacturers and owners have in their power to use that may be relied upon to largely diminish the danger. The first is in the use of a perfect automatic pop safety valve, absolutely certain in its action, prompt in opening and closing, and fully sufficient in capacity to relieve the boiler from any excessive pressure beyond the amount intended to be carried as a safe limit. For its location see plate "The American Type Locomotive," part numbered 201.*

While steam gauges may become deranged from improper care or a wrong method of connection to the boiler, the pop safety valve is generally very reliable and its adjustment should never be changed without the proper authority from someone who absolutely knows, from the application of a test gauge, that the valve requires change of adjustment.

*The Safety Valve is described, and another illustration thereof given, in another volume relating to Motive Power.

THE COALE POP SAFETY VALVE AND MUFFLER.

This is a distinct design of safety valve and is largely used. Its form of construction makes it responsive to and restrictive of steam under variable pressures. Though possessed of large discharging power it gives adequate warning before blowing hard, thus enabling the fireman to control his fire or regulate the supply of feed water before strong "popping" occurs. Used on high pressure boilers, it opens and closes gradually, thus preventing excessive strains upon the boiler.

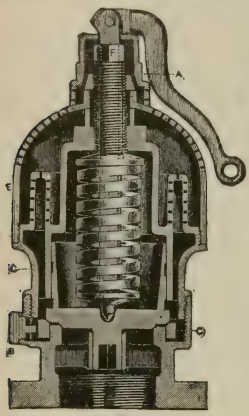


FIG. 1.
The Coale Pop Safety Valve and Muffler.

By means of the spring bolt and adjustable ring both the points of opening and closing may be changed without removing the valve or reducing the steam in the boiler. The construction of the muffler reduces the noise of the escaping steam to a minimum. This feature frequently prevents the frightening of horses and also the annoying interruptions to telegraph orders at stations, should the locomotive be blowing off.

The valve is guarded above and below the seat; at the latter point by a central sectional hub.

The guide wings are removed as far as possible, to allow for contraction and expansion, and also to prevent grooving of the valve seats by steam passing by the guide wings.

The central sectional guide bearing for the valve stem consists in dividing the ring bearing into arc sections between the arms, in order to overcome the effect of uneven expansion and contraction of metals. By this method the guide bearing insures vertical reciprocation of the valve.

To Adjust the Valve.—If a change of pressure be desired, unscrew the cap (*A*) and screw down or up the adjusting screw (*F*), according to whether more or less pressure is desired. To regulate the opening and closing action of the valve, unscrew the bolt (*B*), and by means of any pointed instrument the adjustable screw ring (*C*) may be readily moved either to the right or left. Should the valve close with too much drop of boiler pressure, move the screw-ring (*C*) to the left, a notch or two at a time, until sufficient change has been accomplished. To increase the pop, move ring (*C*) to the right. After the valve is adjusted to suit the requirements, replace bolt (*B*) and cap (*A*).

To examine the inside of the valve, unscrew the cap (*A*) and spring-bolt (*F*), so as to relieve the spring's tension, remove the set screws, and the dome (*E*) and case (*G*) may then be unscrewed and the internal parts of the valve are exposed.

STAR LOCOMOTIVE POP SAFETY VALVES.

An efficient form of "open" or plain locomotive pop safety valve is shown in Figs. 2 and 3. As will be seen from the latter (the sectional view) the spring is encased in a chamber, thereby being protected from the escaping steam. The spring discs or seats, both top and bottom, are pivoted, in order to overcome all

liability of an imperfect bearing of the spring upon its valve.

FIG. 2.
Exterior View.

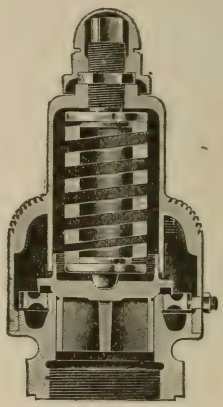


FIG. 3.
Sectional View.

The Star Improved Open or Plain Locomotive Pop Safety Valve.

Figs. 4 and 5 illustrate the muffled Star pop safety valve, which is seen to be similar in construction, with the addition of the top hood, or "muffler," which tends to greatly reduce the noise of the escaping steam, and hence is of considerable advantage. Both the plain and the muffled valves have large relief powers, and are made to withstand the highest pressures used on locomotives. The slotted domes and mufflers have their real aim in preventing dirt and cinders from entering the interior of the valve and clogging its free action. All liability of back pressure on top of valve, which causes continual chattering, is removed.

By removing the small set screw, shown at the right

of both types of valves shown, and turning the ring within to the right or left with a pointed instrument,

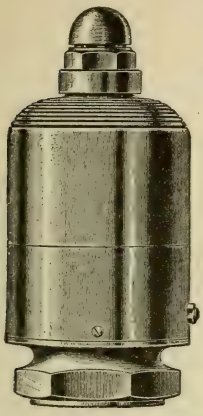


FIG. 4.
Exterior View.

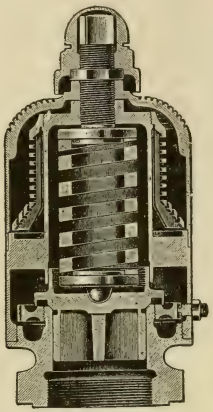


FIG. 5.
Sectional View.

The Star Improved Locomotive Muffled Pop Safety Valve.

the discharge when the valve "pops" will be greater or less correspondingly.

MEADY MUFFLED LOCOMOTIVE POP SAFETY VALVE.

The cut, Fig. 6, represents the Meady muffled locomotive pop safety valve, showing its internal construction. It will be observed that the valve proper projects upward through the perforated casing of the valve, enclosing within it the spring which holds it to its seat; and the upper or outward side of the valve is open to the air at all times, so that when

the valve is discharging it is free from any pressure of the out-going steam, which escapes through the perforated casing into the open air without a disturbing noise.

By this design there is no back pressure on the valve, and its component parts so co-operate that the valve rises when it opens to a greater height than is usual in valves of this character.

For tension of the spring and the adjustment of the parts, means are conveniently arranged and provided. A lever is furnished when desired. In size and utility it is believed to afford all the advantages which are demanded, and to meet all the requirements of an exacting railroad service.

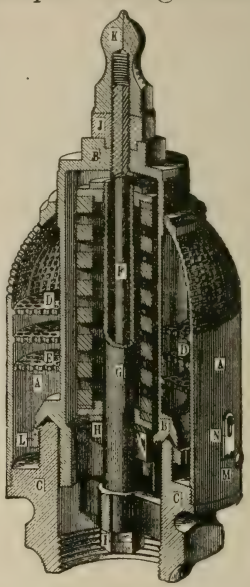


FIG. 6.
Meady Muffled Locomotive Pop Safety Valve.

Directions.—It should never be meddled with unless it becomes necessary to reset it. In such case, first loosen or remove the acorn check nut (*K*) above the spring bolt (*F*); then holding with a wrench the hexagonal top (*B*) of the valve, with another wrench turn the nut (*J*) downward to increase, and upward to reduce the pressure, until the valve opens at the desired point as indicated by the steam gauge. To modify the loss of pressure in blowing, slightly withdraw the screw bolt (*M*) in the base of the valve until it ceases to engage with the ring (*L*) encircling the valve seat (*C*), then with any pointed instrument

inserted into the small opening (*N*) near the screw bolt, turn the ring (*L*) downward for diminishing, and upward for increasing the loss.

CROSBY LOCOMOTIVE POP VALVES.

Fig. 7 shows in section a Crosby plain pop safety valve. The valve proper (*B B*) rests upon two flat annular seats (*V V*) and (*W W*) on the same plane, and is held down against the pressure of steam by the steel spiral spring (*S*). The tension of this spring is increased by screwing down the threaded bolt (*L*) at the top of the cylinder (*K*). The area contained between the seats (*W*) and (*V*) is what the steam pressure acts upon ordinarily to overcome the resistance of the spring. The area contained within the smaller seat (*W W*) is not acted upon until the valve opens.

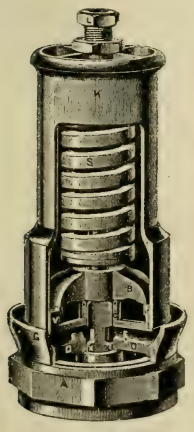


FIG. 7.
Sectional View
Crosby Locomotive Pop
Safety Valve.

The larger seat (*V V*) is formed on the upper edge of the shell or body (*A*) of the valve. The smaller seat (*W W*) is formed on the upper edge of a cylindrical chamber or well (*C C*), which is situated in the center of the shell or body of the valve, and is held in its place by arms (*D D*), radiating horizontally, and connecting it with the body or shell of the valve. These arms have passages (*E E*) for the escape of the steam or other fluid from the well into the air when the valve is open. This well is deepened so as to allow the wings

(*X X*) of the valve proper to project down into it far enough to act as guides, and the flange (*G*) is for the purpose of modifying the size of the passages (*E E*) and for turning upward the steam issuing therefrom.

Action of the valve when working under steam is as follows: When the pressure under the valve is within about one pound of the maximum pressure required, the valve opens slightly, and the steam escapes through the outer seat into the cylinder and thence into the air; the steam also enters through the inner seat into the well, and thence through the passages in the arms to the air. When the pressure in the boiler attains the maximum point, the valve rises higher and steam is admitted into the well faster than it can escape through the passages in the arms, and its pressure rapidly accumulates under the inner seat; this pressure, thus acting upon an additional area, overcomes the increasing resistance of the spring and forces the valve wide open, thereby quickly relieving the boiler. When the pressure within the boiler is lessened the flow of steam into the well also is lessened, and the pressure therein diminishing, the valve gradually settles down; this action continues until the area of the opening into the well is less than the area of the apertures in the arms, and the valve promptly closes.

The point of opening can be readily changed while under steam by screwing the threaded bolt (*L*) up for diminishing, or down for increasing the pressure.

The seats of this valve are flat, and do not cut or wear out and leak so readily as bevelled seats. The valve is made of the best gun metal.

Directions for Setting.—Screw the head-bolt (*L*),

Fig. 7, which compresses the spring, up for diminishing, or down for increasing the pressure until the valve opens at the pressure desired, as indicated by the steam gauge; secure the head-bolt in this position by means of the lock-nut; for regulating the loss of escaping steam, turn the screw ring (*G*) up for increasing, or down for decreasing it.

Directions for Repairing.—This valve having flat seats on the same plane is very easily made tight if it leaks by following these directions, viz.: With an ordinary lathe slightly turn off the two concentric seats of the valve and valve shell or base, respectively, being careful that this is done in the same plane, and perpendicular to the axis of the valve. The valve will then fit tightly on the valve shell. If no lathe is at hand then grind the valve proper on a perfectly flat surface of iron or steel, until its two bearings are exactly on a plane and with good, smooth surfaces; then take the shell and grind its seats in precisely the same manner; rinse both parts in water and put together, and the valve will be found to be tight; to ascertain when the bearings are on the same plane, use a good steel straight edge. Do not grind the valve to its seats on the shell by grinding them together, but grind each part separately, as above stated.

Other types of Crosby plain and muffled pop safety valves are shown in the four next succeeding engravings. Figs. 9 and 11, both sectional views, also show the lever with which these valves are supplied when so desired. It is quite customary to supply a cap which may be locked over adjusting nut (*L*), Fig. 7, so that no one without a key can alter the adjustment of the valves.

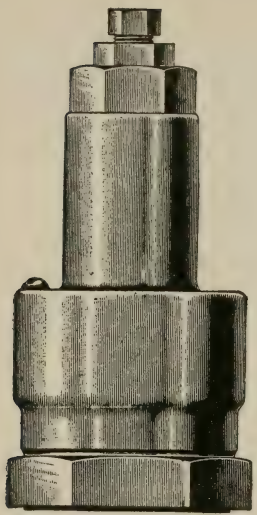


FIG. 8. External View.

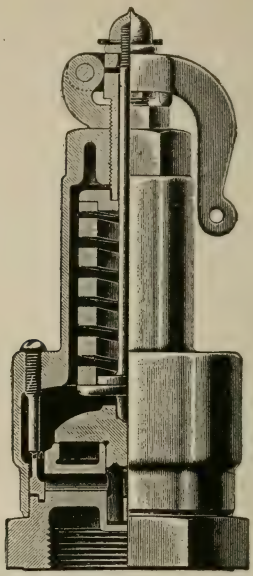


FIG. 9. Sectional View with Lever.

Crosby Plain Locomotive Pop Safety Valves.

FIG. 10. External View.

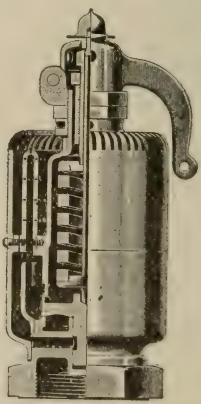
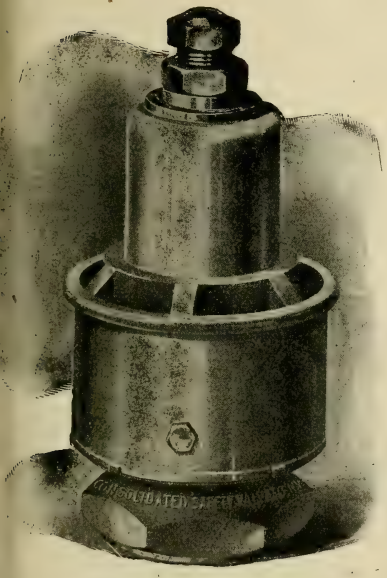


FIG. 11. Sectional View with Lever.

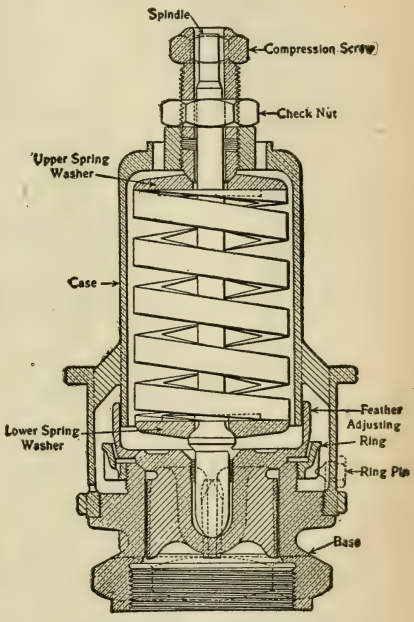
Crosby Muffled Locomotive Pop Safety Valves.

CONSOLIDATED LOCOMOTIVE POP SAFETY VALVES

All locomotive apparatus, especially in bad water districts, is necessarily subjected to frequent inspection and should, therefore, be designed with reference to the usual roundhouse facilities for this work. For such reasons the the locomotive forms of safety valves, while incorporating the



Consolidated Encased Valve



Consolidated Encased Valve —Sectional View

general construction of all Consolidated Valves, have special features, designed to meet the exacting requirements of locomotive service and facilitate their inspection and repair.

The encased valve and the muffler, have identically the same construction, all parts being interchangeable except for

the two muffler shells, which are added to the open valve in making the muffler. The practical advantage of this feature is evident. The same gauge, instructions, or set of repair parts apply to both valves. In fact a muffler valve can be converted into an encased one by merely removing its muffler shells.

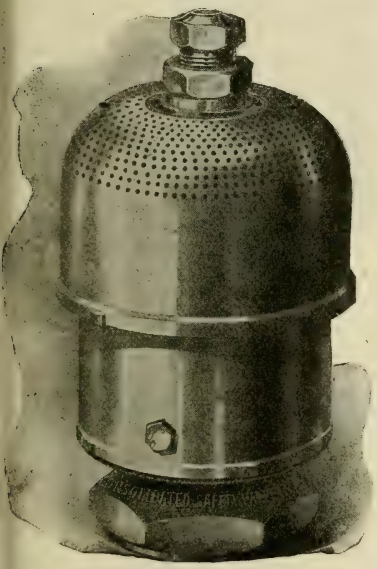
Another equally important advantage results from this form of construction. When it becomes desirable to clean the muffler shells of lime or other sediment, either by reaming out the holes or by immersion in an acid bath, it is not necessary, to remove the valve from the locomotive, or even to alter either of its adjustments. The outer muffler shell is merely unscrewed, both shells lifted off and taken to the bench for cleaning. This removing of the muffler may, of course, be done while the engine is under steam. In fact, if it is not convenient to clean the shells at once, the engine can make a trip or two with them off. The valve will work perfectly as an encased valve, under these conditions, until the shells are ready to be replaced.

The open construction of the compression screw and check nut at the top does away with the cap of other designs. These caps are inconvenient and unnecessary. They restrict the amount of metal upon the top head of the compression screw and also its length, at the top, available for taking up wear. Further they must be taken completely off and replaced whenever adjusting the valve. As a result roundhouse men frequently remove them or turn off their tops. In adjusting the Consolidated valve, on the other hand, it is merely necessary to loosen the check nut a fraction of a turn. This nut cannot be lost or removed over the top of the compression screw for the screw has a large heavy head that will stand, without crushing, the rough usage it is apt to receive. Also the threaded part of the screw above the check nut, available for taking up wear, has been left exceptionally long.

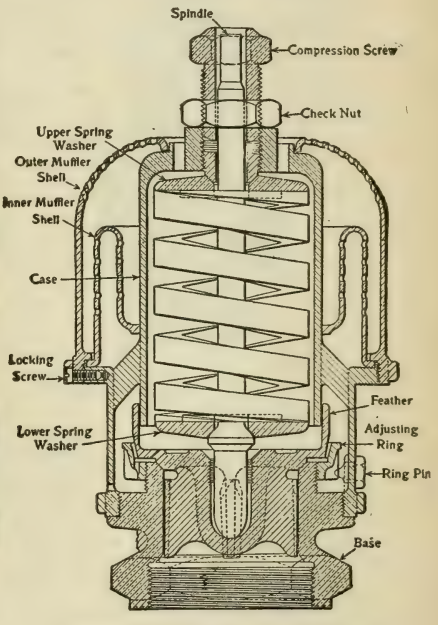
The steam discharge from these valves is all vertically upwards, there being no side blow or spreading out of the steam to cloud the cab windows. This desirable result is obtained by placing the spring case vent holes at the top of the case instead of at the side and by drilling the outer

muffler shell in a special jig, by which the direction of the holes is kept nearly vertical.

The principal features of these valves are the exceptionally large springs with their correspondingly low fibre stresses; the flexible mounting of both ends of the spring with top and bottom washers, which are interchangeable and bear each upon a sensitive balled joint at the center; the long, broad-faced



Consolidated Muffler Pop Safety Valve



Consolidated Muffler Pop Safety Valve—Sectional View

wing guides of the valve feather, or disc; the low spindle bearing upon feather; the outside overlap of the feather trunk upon the case above, over (not into) which joint the steam discharge flows. This construction leaves no area upon the top of the disc or feather, exposed to the steam pressure in the valve case.

THE ASHTON POP SAFETY VALVE

This valve is made both open and with muffler. It is a particularly efficient valve and used very extensively on locomotives throughout the country.

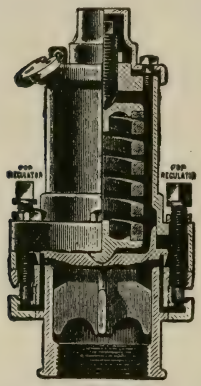


FIG. 15.
Ashton Open Pop Safety Valve.

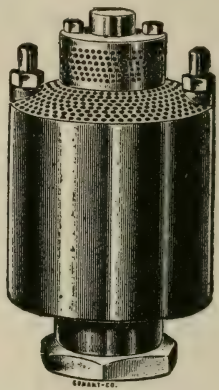


FIG. 16.
Ashton Muffler.

These valves may be regulated from the outside top of the pop and are ordinarily provided with a lock for securing the cap and thus preventing the adjustment being tampered with by irresponsibles.

LOCOMOTIVE INJECTORS.

This chapter, while devoted to locomotive injectors, does not pretend to treat them in their entirety; it does, however, contain brief descriptions and practical information on various types in common use on locomotives.

The injector was patented in 1858 by Giffard, an eminent French engineer, and was introduced into this country in 1860.

There is a great diversity of opinion as to the theory of how an injector works, yet that generally accepted is that an injector works because the great velocity of escaping steam has the power to impart sufficient velocity to the feed water to overcome the pressure of the boiler. In other words, a jet of steam, under a high velocity, strikes the column of water, and, mingling with it, carries it on into the boiler, the water in the boiler being a passive body.

Technically speaking, the *kinetic*, or moving, energy of the jet of combined steam and water overcomes the *static* energy, or state of rest, that exists within the boiler. A stone suspended from a cliff has stored within itself the same energy as that of the boulder which has just gone crashing into the chasm below; the former is said to have static energy, the latter kinetic

It may here be permissible to use a rude comparison to show the effect of moving force upon standing force. Imagine two cars of equal weight on level track, one at rest and the other moving. When they come

together, as any practical railroad man knows, the result will be that the moving car will push the other ahead of it, and itself move on beyond the point where they struck. If necessary we could even see that should the moving car be much lighter in weight than the other, the effect would be the same to a degree. Thus, at the boiler check we again have the place of coming together of two forces—the stationary force from within acting simply on top of the check, beyond which it cannot escape, and the moving force of the jet of combined water and steam from the injector, which can and does not only crowd back the standing pressure, but itself passes beyond the check and enters the boiler.

It has long been a general belief that the fact that the check was below the water level of the boiler accounted for the working of the injector, but this has been proven to be untrue. An injector will work with the check above the water in a boiler, but the circulation in the boiler will be less perfect by reason thereof, and more difficulty will be experienced in keeping the check from leaking.

Inasmuch as some injector makers prefer to retain the piston theory of an injector's working, it is but fair that it should be given and the reader permitted to select that most compatible with his own line of reasoning. The piston theory is that the steam flowing into the large end of the steam tube is condensed by the water, the combined mass practically forming a piston, against which the steam acts, and as the area of the large steam end of the tube is greater than the area of the throat of the discharge tube, the water is forced into the boiler.

Specially constructed injectors used for boiler testing or for washing out boilers are sometimes made to deliver a pressure four or five times as great as the pressure of steam used in operating them. To accomplish this the steam end of the tubes have a larger area than with an ordinary injector.

There are many different classes of injectors, the principal types used differing in having a single or double set of tubes, fixed or adjustable tubes, and open or closed overflow. Each one of these classes may be either lifting or non-lifting, restarting automatically or not.

Injectors in General.—The locomotive injector, no matter of what type or style, is a delicate apparatus requiring care in operation and immediate attention when its work is defective, if the best results are to be obtained. Both the lifting and non-lifting kinds are capable of working with a high temperature of feed water, yet it is not desirable to heat the feed water much in excess of 90 or 100 degrees Fahrenheit. Besides the injury to the paint on the tank, it has been found by careful tests that the hotter the combined delivery of steam and water from the injector, the more quickly the injector nozzles and tubes and the delivery or "branch" pipe will become filled with lime and its proper action become impeded.

With each form of injector, and with the different qualities of feed water used, the length of time an injector should be allowed to work before it is given attention will vary. However, it is safe to say that there are few localities where it would not be advantageous to remove the injector and place it in a bath of ten parts of water to one part of muriatic acid once a month, and between these

periods run a quart of acid through the injector without removing it from the locomotive.

Instructions General to All Injectors on locomotives carrying steam pressure above 180 pounds:

Set the lifting injector just above the highest level of the water in the tank and the non-lifting injector below the lowest level of the water in the tank.

Cold water in the tank is best for the injector. Hot water reduces its life and efficiency. At 120 degrees temperature the capacity is about one-third below the normal. The range of capacities is reduced and no injector lifts as promptly with feed water at temperatures above this.

Use large suction pipe and tank valve connections. If the diameter is increased one size, the gain in capacity is from five to ten per cent. Use large strainers with small holes. Small strainers require frequent cleaning. If the holes are large, cinders and coal pass through and wear the injector tubes. If the strainer is too small, the injector does not give full capacity. Be sure that the gasket between hose and suction pipe is not squeezed so as to close the opening. The suction pipe must be absolutely tight; any leak of air reduces the capacity and makes the overflow valve jump.

Delivery pipe and main check valve must be of ample area. If an injector gives high back pressure it is using too much steam. If the delivery opening is too small, the power of the injector is wasted in increased friction in the pipes.

Causes for Various Injector Defects.—Waste at

the overflow when the steam pressure drops.—Because the tubes are designed for higher pressures, and too much water enters for the steam to force into the boiler.

When an injector delivers more water at low steam pressures.—The tubes are designed for the lower pressure and not enough water can enter the combining tube to condense the steam—the vacuum inside this tube is less strong, and not as much water is lifted.

When an injector will not take hot water.—The opening of the combining tube is too small to permit sufficient water to enter to condense the steam.

When an injector breaks if the valve is throttled.—The steam is not condensed and the overflow is too small to allow it to discharge freely, so that it is compelled to blow back into the suction pipe.

When an injector works better with the steam valve throttled.—The steam nozzle is too large; throttling the steam reduces the amount to be condensed and increases the vacuum in the combining tube, increases the capacity and enables the engine to steam better.

When an injector gives a very high back pressure. —The steam nozzle is larger than necessary to do the work of forcing the water into the boiler, and too much live steam is required.

It is so self-apparent as to require no reasoning, that every engineer placed in charge of a locomotive, and whose safety and that of the lives in his charge depends upon a proper supply of water to

the powerful boiler he is operating, should thoroughly understand the construction and manipulation of the injectors on his locomotive, or on other locomotives which he may be called upon to run any day. He should also be prepared to proceed intelligently and promptly in case his injector fails to do its work perfectly.

SELLERS' CLASS N IMPROVED SELF-ACTING INJECTOR.

This self-acting injector is designed especially for locomotive use. It operates equally well when supplied with water under pressure or when it is placed above the level of the water supply, provided the height of lift does not exceed fifteen or eighteen feet.

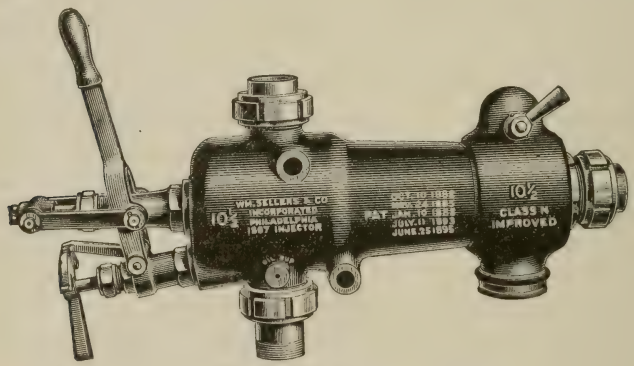


FIG. 1.
Sellers' Class N Improved Self-Acting Injector.

It is mainly on account of its efficient positive action and very wide range of capacities at 200 pounds steam pressure, that it is especially applicable to high-pressure locomotive boilers. It should work

well from the highest steam pressures used on locomotives down to thirty-five pounds steam pressure without adjustment and without wasting at the overflow, and by regulating the water supply valve on the injector, it is claimed to work at ten to fifteen

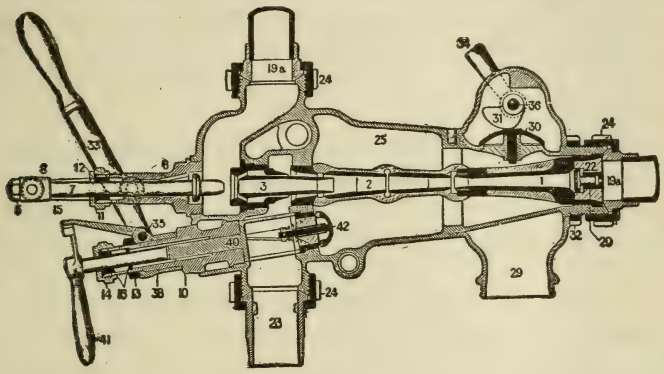


FIG. 2.

Seller's Class N Improved Self-Acting Injector.—(Sectional View).

LIST OF PARTS.

1. Delivery Tube.
2. Combining Tube.
3. Steam Nozzles.
5. Spindle Nut.
6. Steam Stuffing Box.
7. Spindle.
8. Crosshead.
10. Water Stuffing Box.
11. Follower.
12. Packing Ring.
13. Lock Nut.
14. Follower for No. 10.
15. Links.
16. Packing Ring.
19. Plain. } Rings for
19a. Reduc. } Copper Pipe.
20. Check Valve.
22. Guide for No. 20.
23. Plain. } Unions for
23a. Reduc. } Iron Pipes.
24. Coupling Nuts.
25. Injector Body.
27. Wrench.
29. Waste Pipe.
30. Waste Valve.
31. Waste Valve Cam.
32. Jam Nut for No. 29.
33. Starting Lever.
34. Cam Lever.
35. Pin, Nos. 9 and 33.
36. Cam Shaft.
37. Washer on 36.
38. Collar and Index.
39. Funnel.
40. Plug Water Valve.
41. Regulating Handle.
42. Inlet Valve.

pounds. As this injector restarts instantly under all conditions of service, it can well be depended upon.

Its construction is quite simple and it is easy and economical to repair.

This injector has shown most excellent results when the feed water is strongly impregnated with lime. The tubes of all classes of the same size of this injector are interchangeable, thus greatly reducing the extra parts to be kept on hand.

While this injector may be placed wherever it is most convenient for the engineer, it is generally located within the cab or part way through the cab frame.

The action of this injector is as follows: Steam from the boiler is admitted to the lifting nozzles by drawing the starting lever 33 about one inch, without withdrawing the plug on the end of the spindle 7 from the central part of the steam nozzle 3. Steam then passes through the small diagonally-drilled holes and discharges through the outside nozzle, through the upper part of the combining tube 2 and into the overflow chamber, lifts the overflow valve 30, and issues from the waste pipe 29. When water is lifted the starting lever 33 is drawn back, opening the forcing steam nozzle 3, and the full supply of steam enters the combining tube, forcing the water through the delivery tube into the boiler.

At high steam pressure there is a tendency in all injectors having an overflow to produce a vacuum in the chamber 25. In the improved self-acting injector this is utilized to draw an additional supply of water into the combining tube by opening the inlet valve 42, which is forced by the jet into the boiler, increasing the capacity about twenty per cent.

The water-regulating valve 40 is only to adjust the capacity to suit the needs of the boiler. The range is unusually large.

The cam lever 34 is only used to prevent the opening of the overflow valves when it is desired to use the injector as a heater, or to clean the strainer. The joint between the body 25 and the waste-pipe 29 is not subject to other pressure than that due to the discharging steam and water during starting; the metal faces should be kept clean and the retaining nut 32 screwed up tight.

To tighten up the gland of the steam spindle, push the starting lever 33 to end of stroke, remove the little nut 5 and draw back the lever 33. This frees the cross-head 8 and links 15, which can be pushed out of the way, and the follower 12 tightened on the packing, to make the gland steam tight.

Operation.—Open wide the valves in the steam and water supply pipes (not shown). Draw the starting lever 33 slowly all the way back; this lifts the feed water and forces it into the boiler with a single movement. Adjust the capacity with the water-regulating valve 40, by means of the handle 41, to suit the needs of the boiler. If the water in the tank is warm or the suction pipe is hot, or if the injector has not been used for some time and condensed water has accumulated in the steam supply pipe, draw the starting lever 33 back about an inch and wait for the water to appear at the overflow before bringing the lever 33 way back. However, in all ordinary cases the injector should be started without the loss of a large amount of water at the overflow.

To obtain the minimum capacity, adjust the water-regulating valve 40 by means of handle 41 until puffs of steam appear at the overflow, and then open slightly.

The following rules for procedure when this injector fails to do its work perfectly will be found of especial advantage to those handling locomotives equipped with this injector:

When the Injector Will Not Lift.—(1) The suction pipe may be filled with boiling water.—Draw the starting lever 33 back about one inch, close lever over waste valve 34 and when the suction pipe is clear, open quickly, and water will appear at the overflow.

(2) Strainer stopped up.—Use same method as above, and, if not effective, uncouple pipe and clean out strainer.

(3) Obstruction in lifting combining tube.—Uncouple the delivery pipe from the injector and unscrew the tubes; carefully examine all holes and pass a light brass wire through the combining tube 2 and the delivery tube 1 until it strikes the check valve. (The obstruction may have dropped out during the removal.)

(4) Obstruction in the lifting steam nozzle.—Unscrew spindle nut 5 and pull starting lever 33 back, drawing off crosshead 8; remove follower 11 and pull out spindle; unscrew stuffing box 6, slacken lock nut 13 and rotate starting lever out of the way. Unscrew steam nozzles 3 and hold lightly in vise by the square on taper end, using a box wrench on the upper hexagon. When separate, clean very carefully with fine emery cloth until the metal is bright, without altering diameters. If the surfaces are much grooved or cut, substitute new parts.

(5) Inlet valve 42 may be open.—Remove pin 35, unscrew lock nut 13 and swing starting lever 33 out of the way; unscrew water stuffing box 10 and remove

water valve 40; insert light wire to see if inlet valve 42 seats freely; if not, remove with a wrench made of a piece of flat iron. The spring on the valve stem should just close valve when horizontal.

When the Injector Will Lift, But Will Not Deliver the Water into the Boiler.—(1) Suction pipe choked.—This may be shown by steam appearing at the overflow when the starting lever is opened wide, or by the delivery being too hot. The tank valve may be partially closed or hose lining loose. Blow out the suction pipe as described before.

(2) Main check valve stuck on seat.—Shown by a heavy, or by a continuous light overflow. Tap the check valve lightly with a lead hammer; if not effective, cap of valve will have to be removed when engine is not under steam.

(3) Main check valve too small.—Shown by a continuous light overflow or drip. All valves should have openings and pipe connections at least as large as those of the injector. It is usually advantageous to have the suction pipe one size larger.

(4) Obstruction in the tubes.—Uncouple the delivery end of the injector and remove and examine the combining and delivery tubes as before.

(5) Steam nozzle 3 stopped up.—Remove the steam stuffing box 6 and the steam nozzle 3 as before described, and see if the main nozzle is choked.

(6) If the overflow valve 30 vibrates on its seat, and the injector works noisily, look for a leak in the suction pipe. Draw starting lever 33 back about one inch, close waste valve lever 34 and close the tank valve sufficiently to produce slight pressure in suction pipe; examine all joints and seams carefully for leak,

which, with large injectors, may be below the water line.

General Instructions.—(1) Blow out all pipes carefully with steam before attaching the injector, tapping the pipe with a hammer in order to loosen all the scale.

(2) When drip pipe is attached close to overflow of injector, it must be of ample size required.

(3) Always use a dry pipe attachment to insure perfectly dry steam.

(4) The diameter of the strainer should be large enough to give an ample supply of water even when some of the holes are choked.

(5) Keep all valves steam tight; all leaks tend to increase rapidly owing to the velocity with which steam passes through the smallest opening.

(6) A leak at the overflow valve 30 diminishes the capacity of the injector and draws air into the boiler; this valve can be ground without removing the injector from the engine. Unscrew the coupling nut 24 and the jam nut 32 at the delivery end; slide both parts over the boiler feed pipe and follow with the overflow sleeve 29; this uncovers the valve, which may then be ground to a bearing, using only fine sand or powdered quartz.

Repairs.—The parts most liable to wear depend upon the condition of the steam and the feed water. Wet steam cuts out the lifting steam nozzle without affecting the other tubes, while grit or dirt in the supply water wears the outside of the forcing steam nozzle and roughens the tubes. Every injector should work as before described, and, if the steam is dry and the water supply clean, will give long and

satisfactory service. When new combining and delivery tubes are required, remove old tubes from body by means of a special wrench provided for that purpose; hold the delivery tube in a vise and remove piece No. 22 with same wrench; note if shank of check valve or bearing in piece No. 22 are worn too much for use. Screw new parts together without bending, always holding them in vise as close to the threads as possible; then place them between lathe centres and tap lightly with a lead hammer until the hole in the end of the combining tube runs perfectly true. See that the seats on the body and the shoulders of the tubes show clean bright metal; put a little black lead and oil on threads and screw firmly in place.

(2) Keep the steam pipe and chamber free from dirt and chips from the threads on the pipes, and the steam nozzles perfectly clean. The steam nozzle is the life of an injector, and should be maintained in best condition. If the injector is new and the lifting nozzle should fill up, remove from body as previously described and push a piece of card-board down through the annular nozzle, so as to drive out the dirt; it will probably not be necessary to take the nozzles apart.

(3) When grinding the steam valve, screw the steam stuffing box rather tightly against its shoulder to insure its proper alignment, after placing a rubber washer over the holes leading to the lifting nozzle to prevent the sand from working into the lifting jet; this washer should, of course, be provided with a hole large enough to admit the plug on the end of the spindle. Keep the steam valve perfectly tight.

(4) To remove lime and scale, immerse the tubes

or the whole injector in a bath composed of ten parts of water to one part muriatic acid. Remove as soon as scale is dissolved.

(5) It is essential that the tubes and nozzles be

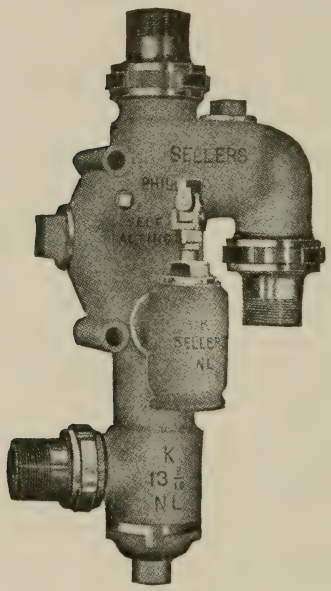


FIG. 3.

Seller's Class K Self-Acting Injector, Non-Lifting.

maintained in good condition, and that the proportions be correct, in order to obtain the best results from an injector. The body of this injector will last a lifetime, but the tubes require occasional

replacing. As these can now be purchased or made at a very low cost, it is not good policy to allow the condition of the injector to run down.

SELLERS' SELF-ACTING INJECTOR CLASS K—NON-LIFTING.

The Sellers' Self-Acting Injector, known as "Class K," which is Non-Lifting, embodies all the advantageous features of the lifting forms, but is designed to receive the water supply under a head, and should be placed below the running-board of the locomotive. The manufacturers claim that this Class K injector overcomes all the serious objections urged against the older forms of non-lifting injectors.

This form is shown by a general view in Fig. 3 and by sectional view in Fig. 4.

It is applicable to all kinds of steam boilers, and is said to be absolutely reliable under the most severe conditions of service. It will start promptly even when the water supply is hot, and the capacity increases with the steam pressure from 30 to 225 pounds, using the same set of tubes.

It is provided with a balanced inlet valve peculiar to these non-lifting injectors. This valve gives an additional inflow of water to the tubes during the operation of the injector, surrounding them with a bath of cold water direct from the water supply, reducing the formation of scale and largely increasing the capacity at high steam pressures without affecting its action at low steam.

This injector is claimed to be restarting—that is, if the water supply is temporarily interrupted the injector will start automatically as soon as the supply is resumed; it is also self-adjusting—requiring no regulation of tank valve or lazy cock to prevent overflow when the steam pressure falls.

This injector is designed for hot water. The limiting temperature of the water supply depends upon the size and arrangement of the water supply pipe and the pressure of the steam.

It is constructed in such a way that the tubes and other parts can be easily taken out for cleaning or repairs. By unscrewing the cap at the lower end the combining and delivery tubes may easily be removed. The overflow valve is closed by a quick-acting cam, requiring only a one-half turn of the extension rod, or by a screw stem, if desired.

Operation.—Open the overflow, water and steam valves. Regulate for quantity with water valve. To use as a heater, or when the water supply is above 106 degrees, close the overflow valve. As the temperature rises toward the limit the capacity is reduced.

NATHAN "SIMPLEX" INJECTOR.

The *Simplex* injector is termed an automatic instrument and will restart, picking up the water after interruption from any cause such as water surging in the tank when supply is low. It is also self-regulating, controlling the water without waste at the overflow with a varying pressure of steam

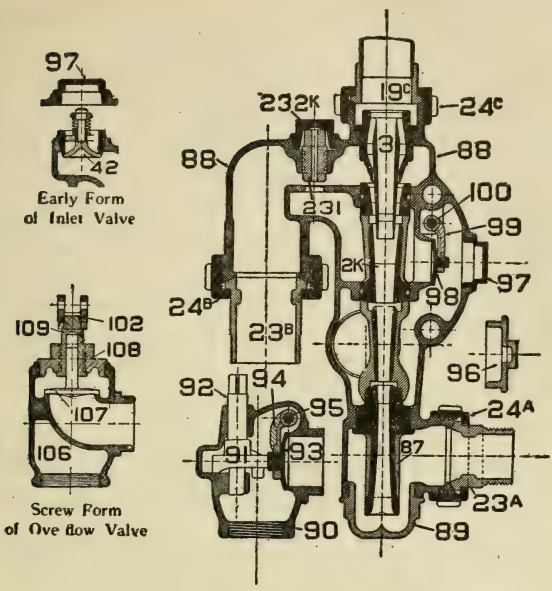


FIG. 4.

Sellers' Class K Self-Acting Injector. Non-Lifting.—(Sectional View).

LIST OF PARTS.

2k. Combining Tube.
3. Steam Nozzle.
19a. Delivery Ring for Copper Pipe.
19b. Water Ring for Copper Pipe.
19c. Steam Ring for Copper Pipe.
23a. Delivery Union for Iron Pipe.
23b. Water Union for Iron Pipe.
23c. Steam Union for Iron Pipe.
24a. Delivery Coupling Nut.
24b. Water Coupling Nut.
24c. Steam Coupling Nut.
42. Inlet Valve (old style).
87. Delivery Tube.
88. Body.
89. Cap at end of Body.
90. Waste Pipe (Cam Pattern).
91. Cam to Close Waste Valve.
92. Cam Shaft.
93. Waste Valve.
94. Hinge for No. 93.
95. Pin through No. 90 and No. 94.
96. Cap opposite No. 90.
97. Cap over No. 98 and No. 42.
98. Hot Water Valve.
99. Hinge for No. 98.
100. Pin for No. 99.
101. Cap for No. 100.
102. Universal Joint.
106. Waste Pipe (Screw).
107. Waste Valve.
108. Cap over No. 107.
109. Screw Stem.
231. Inlet Valve.
232k. Cap over 231.

from 200 pounds down to 50 pounds without any manipulation on the part of the engineer.

Below 50 pounds pressure the water must be regulated by the water valve. It will start readily, even with a hot suction pipe. This injector is provided with an extra water way which is controlled by an inlet valve 19, which valve serves to increase the injector's capacity at steam pressures above 150 pounds.

Should this valve 19 leak or stick off its seat, the key 35 above may be turned one-half turn and thus this extra water way shut off. The injector will then start and work as an ordinary injector.

The range of reduction in this injector is nearly sixty per cent. and is obtained by means of the water valve. The steam valve is supposed to be wide open at all times.

The thumb screw on the lever guide is simply to keep the lever in a slightly open position whenever the injector is used as a heater, so that the entire pressure may not be put on the hose alone.

The only parts liable to need attention are the steam valve and the inlet valve. Should the injector get hot every time when out of use, it is evident the steam valve leaks and should be ground in. In case there is any difficulty in starting the injector, it may be the inlet valve is out of place (or unseated), and in such a case turn the key 35 a half turn, with the letter *S* on the upper face of the square spindle end, and the injector will go to work. At the end of the run this valve may be given the necessary attention.

To use this injector as a heater, close the heater cock check and draw out the starting lever.

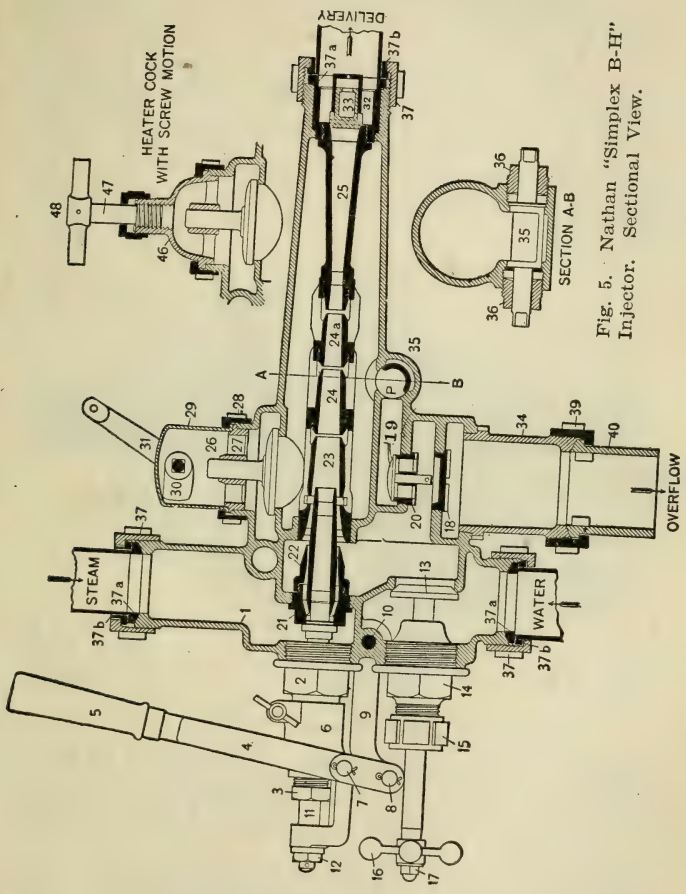


Fig. 5. Nathan "Simplex B-H" Injector. Sectional View.

In starting on high lifts and in lifting hot water, pull out the starting lever slowly.

To start the injector, pull out the lever; to stop, push in the lever.

NATHAN "MONITOR XX" INJECTOR.

The "Monitor XX" injector is a self-contained instrument; that is, it contains within itself all the valves necessary to admit and to regulate the steam and the water supply. It is claimed to work

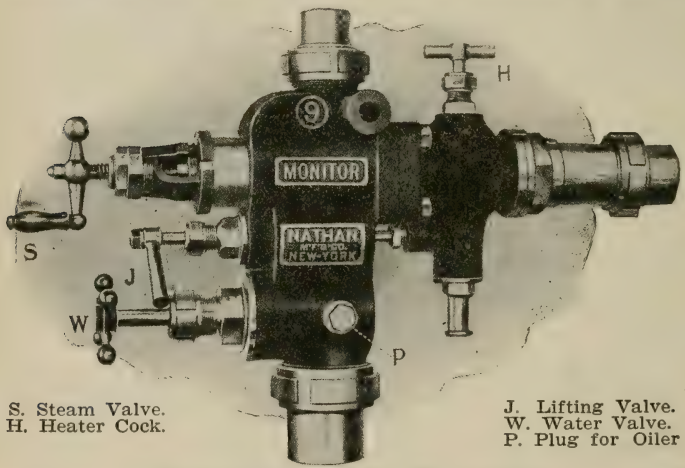


Fig. 6. Nathan "Monitor XX" Injector.

steadily, whether the engine is running fast or slow, with heavy or with light trains, the quantity of water needed being regulated by the water valve.

The body of this injector is made in two parts, bolted together, so that it is possible to replace either of them separately, avoiding the necessity of throwing away the entire body in case only one-

half of it should become useless. It is made with removable seats for the steam and lifting valves, making the body last a much longer time.

This injector is interchangeable with others of corresponding pipe connections.

A general view of this injector is shown in Fig. 6 and a sectional view in Fig. 6A.

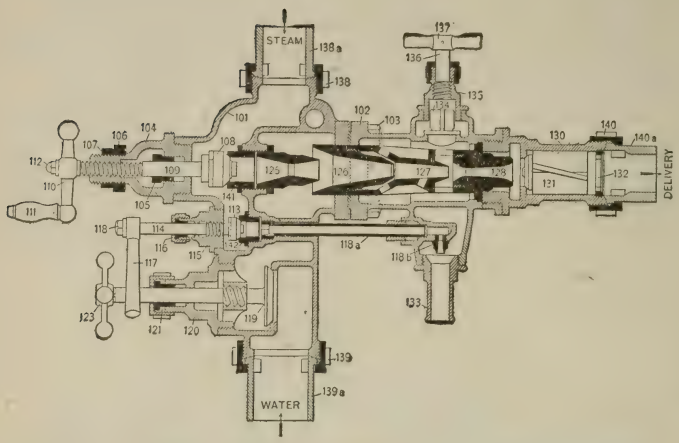


Fig. 6A. Nathan "Monitor XX" Injector. Sectional View.

LIST OF PARTS.

101. Body (Back part).
102. Body (Front part).
103. Body Screw.
104. Yoke.
105. Yoke Gland.
106. Yoke Packing Nut.
107. Yoke Lock Nut.
108. Steam Valve Disc and Nut.
109. Steam Valve Spindle.
110. Steam Valve Handle.
111. Steam Valve Rubber Handle.
112. Steam Valve Top Nut.
113. Jet Valve Disc and Nut.
114. Jet Valve Spindle.
115. Jet Valve Bonnet and Nut.
116. Jet Valve Gland.
117. Jet Valve Lever Handles.
118. Jet Valve Top Nut.
118a. Jet Tube.
118b. Lifting Nozzle.
119. Water Valve.
120. Water Valve Bonnet and Nut.
121. Water Valve Gland.
123. Water Valve Handle.
125. Steam Nozzle.
126. Intermediate Nozzle.
127. Condensing Nozzle.
128. Delivery Nozzle.
130. Line Check Casing.
131. Line Check Valve.
132. Stop Ring.
133. Overflow Nozzle.
134. Heater Cock Check.
135. Heater Cock Bonnet and Nut.
136. Heater Cock Spindle.
137. Heater Cock T Handle.
138. Coupling Nut } Steam End.
138a. Tailpiece. }
139. Coupling Nut } Water End.
139a. Tailpiece }
140. Coupling Nut } Delivery End.
140a. Tailpiece }
141. Steam Valve Seat.
142. Jet Valve Seat.

Operation.—Water valve 119 is opened by handle 123. Open lifting valve 113 by means of lever 117, which admits steam to jet tube 118A and thereby causing a partial vacuum in nozzle 126 by means of communication through overflow chamber, with valve 134 open, drawing water from tank into nozzle 126, and escaping at overflow 133. When water appears at overflow 133 open steam valve 108, which admits steam into nozzles 125, 126, 127 and 128, forcing check valve 131 open and forcing water already in nozzle 126 into delivery pipe, thus supplying the boiler. The water supplied is regulated by means of water valve 119. To cut down water supply, if water valve 119 does not regulate water enough, reduce the quantity of steam supplied. As soon as overflow ceases, close valve 113 and do not increase steam supply any more. To shut off injector close steam valve 108.

To use this injector as a heater close overflow valve 134 and open steam valve 108, but valve 134 should never be closed except when injector is used as a heater.

A small lubricator should be attached to the oiler plug P, Fig. 6, of the injector to lubricate nozzles and prevent incrustation or corrosion.

Whenever the road passes through a section of country where the water is impure or limy, the nozzles should be taken out of the injector frequently and placed over night in a bath of mineral oil or washed in a dilution of sulphuric acid, to remove deposits from surface.

"NATHAN" NON-LIFTING INJECTOR.

The "Nathan" injector of the non-lifting type embodies all the advantageous features claimed

for lifting injectors, but must be placed below the lowest water level of the tank so that the water will flow to it, but unlike other injectors so placed, it is provided with a priming jet, and what is the novel feature in it, the overflow is placed above the highest water level in tank, convenient to the engineer in the same manner as in a lifting injector, connecting with the overflow space in the injector body by means of a single piping, which can be applied and located in any convenient, unrestricted place.

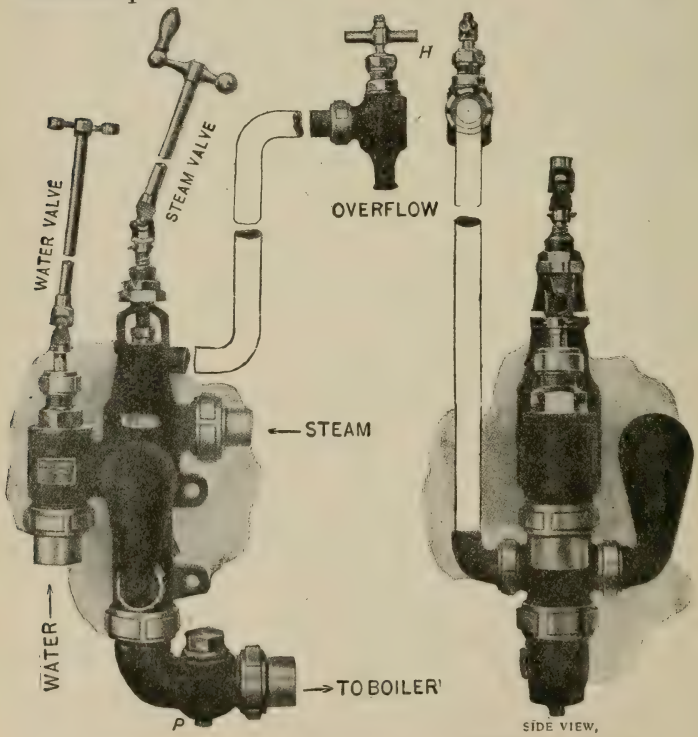


FIG. 6B. Nathan "Non-Lifting" Injector.

A few of the claims made for this injector, which is shown by a general view in Fig. 6B and a sectional view in Fig. 6C, may be summed up as follows:

1. It will start readily at all times and under all circumstances. Hot suction, leaks and defective boiler checks, which cannot always be avoided, will not affect its prompt starting.
2. It will not lose in capacity, when used with higher steam pressure than the one for which it was originally intended.
3. It will not lose more water in starting than any lifting injector, as the overflow is in sight of the engineer, and there is no necessity for looking for it outside the cab.
4. When once regulated to the requirements of the service, it is a one-motion machine. Simply turning on the steam valve will infallibly start it.
5. The nozzles of this injector will not corrode, as the body is comparatively cool, being always charged with water.
6. Steam from a leaky steam valve will not show at the overflow.

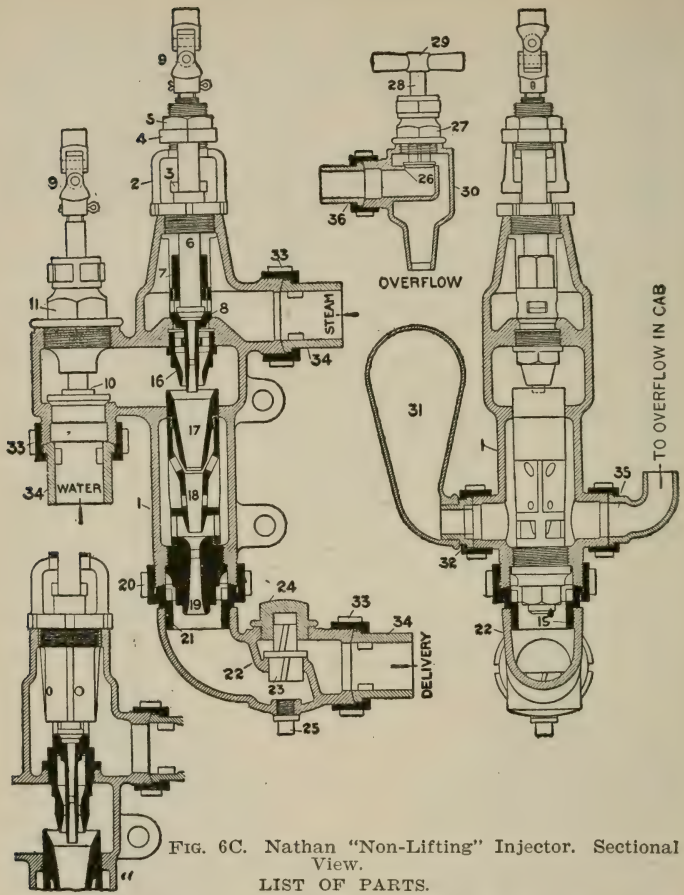


FIG. 6C. Nathan "Non-Lifting" Injector. Sectional View.

LIST OF PARTS.

1, Body; 2, Yoke; 3, Yoke Gland; 4, Yoke Packing Nut; 5, Yoke Lock Nut; 6, Steam Valve Spindle; 7, Steam Valve Lock Nut; 8, Steam Valve and Priming Nozzle; 9, Universal Joint; 10, Water Valve; 11, Water Valve Bonnet and Nut; 16, Steam Nozzle; 17, Intermediate Nozzle; 18, Condensing Nozzle; 19, Delivery Nozzle; 20, Line-check Nut; 21, Line-check Nipple; 22, Line-check; 23, Line-check Valve; 24, Line-check Cap; 25, Drain Plug; 26, Heater Cock Check; 27, Heater Cock Bonnet and Nut; 28, Heater Cock Spindle; 29, Heater Cock Handle; 30, Overflow Body; 31, Air Chamber; 32, Air Chamber Nut and Nipple; 33, Coupling Nut—Steam, Water or Delivery; 34, Tailpiece—Steam, Water or Delivery; 35, Lower Overflow Nut and Tailpiece; 36, Upper Overflow Nut and Tailpiece.

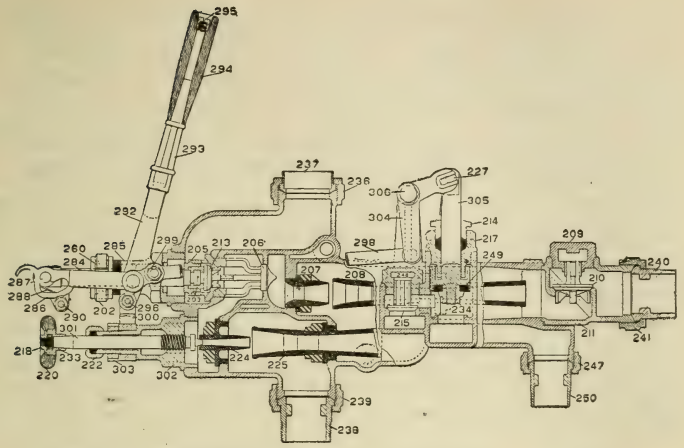


FIG. 7. Metropolitan "Model H" Locomotive Injector.

LIST OF PARTS.

202	Packing Nut for No. 285.	248	Overflow Valve Cap.
203	Champ Ring.	249	Disc for Overflow Valve.
205	Steam Swivel Ring.	250	Tail Pipe for Overflow Nozzle.
206	Steam Valve.	260	Steam Packing Gland.
207	Forcing Steam Jet.	284	Steam Valve Stem.
208	Forcing Combining Tube.	285	Steam Center Piece.
209	Check Valve Cap.	286	Side Links.
210	Check Valve.	287	Pin for Steam Stem.
211	Check Valve Casing.	288	Spring.
213	Auxiliary Steam Valve.	289	Outflow Valve Crank Bolt Nut.
214	Packing Gland for No. 305.	290	Bolt for Side Links.
215	Overflow Valve.	291	Nut for Bolt for Side Links.
217	Overflow Center Piece	292	Lever.
218	Regulating Valve Handle Nut.	293	Handle Rod.
220	Regulating Valve Wheel.	294	Wood Handle.
222	Packing Nut for No. 302.	295	Handle Nut.
224	Lifting Steam Jet.	296	Fulcrum Bolt.
225	Lifting Combining Tube.	297	Nut for Fulcrum Bolt.
227	Overflow Valve Pin.	298	Connecting Bar.
231	Stud Bolt.	299	Nut for Connecting Bar.
233	Regulating Valve Wheel Disc.	300	Fulcrum Collar.
234	Nut for Overflow Disc.	301	Regulating Steam Stem.
236	Union Nut, Steam End.	302	Regulating Center Piece.
237	Tail Pipe, Steam End.	303	Fulcrum Nut.
238	Tail Pipe, Suction End.	304	Overflow Valve Crank.
239	Union Nut, Suction End.	305	Overflow Valve Stem.
240	Tail Pipe, Delivery End.	306	Overflow Valve Crank Bolt.
241	Union Nut, Delivery End.		
245	Nut for Stud Bolts.		
247	Union Nut for Overflow Nozzle.		

Operation.—Open steam valve 8, slowly at first until overflow runs dry, regulating for quantity by water valve. The steam supply should not be increased after the overflow has ceased.

In order to cut down the injector, the water and steam supply should be reduced to the desired degree.

The water valve need not be handled when it is once regulated to the requirements of the service. Leaving it open will keep the body charged with water and prevent corrosion of the nozzles.

To use this injector as a heater close heater cock 26 and open steam valve 8. At all other times cock 26 must be wide open.

METROPOLITAN LOCOMOTIVE INJECTOR.

The Metropolitan "Model H" Locomotive Injector is a double-tube injector, composed of a lifting set of tubes which lift the water and deliver it to the forcing set of tubes under pressure, which in turn force the water into the boiler.

The lifting set of tubes act as a governor to the forcing tubes, delivering the proper amount of water required for the condensation of the steam, thus enabling the injector to work without any adjustment under a great range of steam pressure, handle very hot water and admit of the capacity being regulated for light or heavy service under all conditions.

This injector will start with 30 to 35 pounds steam pressure, and, without any adjustment of any kind will work at all steam pressures up to 300 pounds. It

is claimed that at all steam pressures and under all conditions its operation is the same. When working, all the water must be forced into the boiler. It is impossible for part or all the water to waste at the overflow should the steam pressure vary.

The independent lifting apparatus produces a strong, powerful vacuum, which enables the injector to promptly lift the water when subjected to the severe conditions of a hot suction pipe, leaking check valves, and hot water supply.

This injector will handle very hot feed water. It starts readily, taking feed-water at 140° Fahr. with steam pressures up to 150 pounds, and 135° Fahr. with a steam pressure of 175 pounds, and 130° Fahr. with a steam pressure of 200 pounds.

Regulation of capacity is an important, in fact indispensable, feature of the perfect locomotive injector. With this injector the capacity can be regulated for light or heavy service under all steam pressures and with hot as well as with cold feed water.

To Connect and Operate.—Place the injector above the level of the water in the tender within reach of the engineer. Take steam from the dome through a dry pipe; should the injector be placed outside the cab, extension fittings must be used.

To Start the Injector.—Pull the lever back slightly until the resistance of the main steam valve is felt. This lifts the water. As soon as the water is lifted, pull the lever back steadily as far as it will go. The injector will then be feeding. Do not push lever in to regulate the feed; it must be pulled back as far as it will go.

***To Regulate the Feed.*—To increase the capacity**

turn the wheel to the left. To decrease the capacity turn the wheel to the right.

To Use as a Heater.—Close the overflow valve by disconnecting the connecting bar and pulling it back. Admit steam by pulling the lever slightly.

General Suggestions for Piping and Making Repairs.—The Injector is preferably located inside the cab thus being directly under control of the engineer. It is necessary that the steam pipe and the opening in the main steam valve be as large as the steam connection so that the injector will receive a full supply of steam. If it does not receive a full supply of steam it will be sensitive or refuse to work at all. The suction and delivery pipes must also be large.

Repairing.—The forcing combining tube 208 is subject to the greatest wear, also to incrustation from limy or impure water. When this tube shows signs of wear, if but little, the roughened part can be smoothed. If the wear is considerable a new tube should be inserted. In time the forcing steam jet 207, the lifting steam jet 224, and the lifting combining tube 225, will wear and should be renewed. The automatic overflow valve 215 must be tight, and if it does not seat tight it should be promptly reground. If this valve leaks it will allow the water discharged from the forcing combining tube 208 to flow back and heat the water between the lifter and the forcer so that the injector will break.

The final overflow valve is made with a special disc 249, which is soft. This prevents any damage being done to the valve seat. These discs are inexpensive, easily renewed, and do away with the

grinding of the valve to its seat. Should the steam valve, 206 and 213, leak, it should be reground promptly.

The sectional view shows the injector with the vertical form of check valve. If the feed water is limy or impure, a swing check valve, as illustrated and described elsewhere, should be used. The lever movement as shown in the diagram is the improved lever attachment. The first Metropolitan "1898" locomotive injectors made had a different form of lever attachment.

THE HANCOCK LOCOMOTIVE INSPIRATOR.

The difference between an inspirator and an injector is that the former is a double apparatus having both lifting and forcing jets and tubes combined, and operating with a closed overflow, while the lifting injector has these two parts independent one from the other.

The type of Hancock inspirator of which Fig. 8 is a general and Fig. 9 a sectional view, is designed to meet the demand for an instrument of the class which is operated by one lever or handle. The regulating valve 105, which is directly under the lever, throttles the steam supply to the lifter steam nozzle only, thereby reducing the capacity of the inspirator from the maximum to the minimum without the use of a "lazy cock."* This arrangement neither disturbs the suction by creating an increased vacuum in the pipe, nor impairs the effectiveness of the forcing apparatus.

* "Lazy Cock" was the term applied to the valve formerly located in the feed-water pipe, by the opening and closing of which the regulation of the amount of feed-water supplied was effected.

Pipe Connections.—To obtain the best results, locate the inspirator with the overflow nozzle 108 about four inches above the water in the tank. Take the steam direct from the dome or highest part of the boiler, and not from a pipe which furnishes steam for

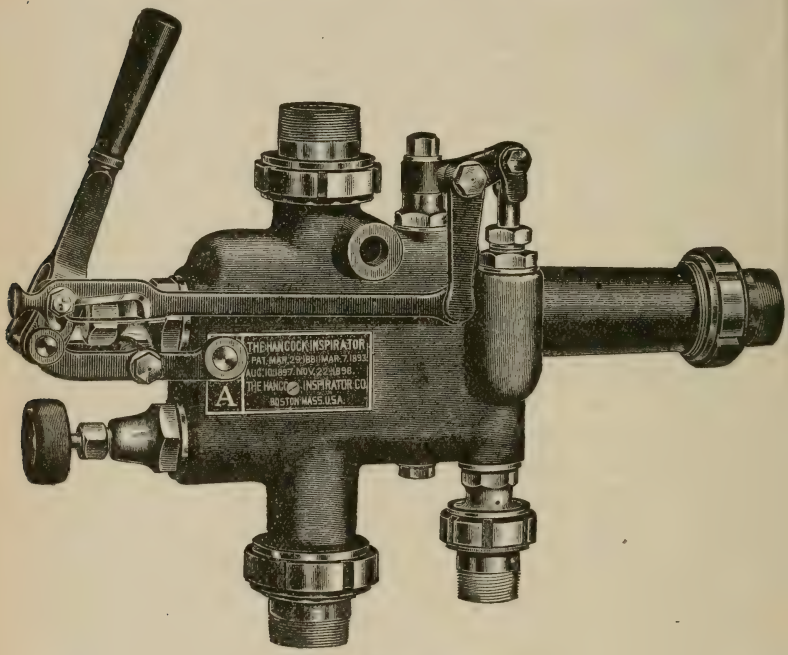


FIG. 8.
Hancock Locomotive Inspirator.

other purposes. Place a globe valve in the steam pipe, and blow it out thoroughly before connecting the inspirator, to remove any redlead, chips, etc.

All openings in the steam connections from the inspirator to the dome and the openings in the suction

or feed-pipe connections from the inspirator to the tank must be of ample size. The overflow pipe should be the full size of the inspirator connection and as nearly straight as possible. The end of the overflow pipe must be open to the air, and not piped below the surface of the water.

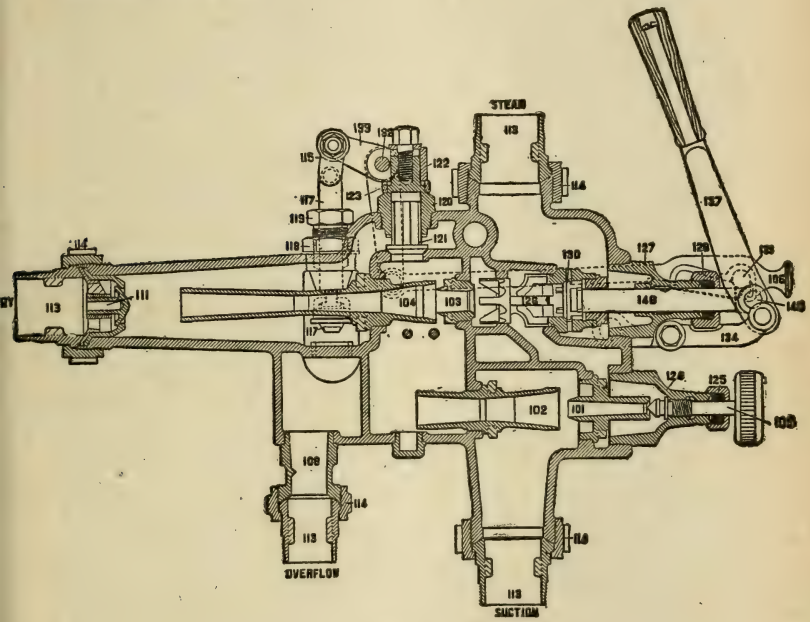


FIG. 9.
Hancock Locomotive Inspirator.

Operation.—To start the inspirator draw the lever back to lift the water, then draw it back *slowly* to the stop. When the lever 137 is drawn back slightly, steam is admitted to the lifter steam valve 130 through the forcer steam valve 126 to the lifter steam nozzle 101. The velocity of the steam into the lifter com-

bining tube 102 creates a vacuum, and causes the water to flow through the lifter combining tube 102, condensing the steam, and out through the intermediate overflow valve 121 and through the final overflow valve 117 in the delivery chamber. A further movement of the lever 137 opens the forcer steam valve 126 admitting steam to the forcer steam nozzle 103 and to the forcer combining tube 104, and creating a pressure in the delivery chamber sufficient to close the inter-

LIST OF PARTS FIG. 9.

101. Lifter Steam Nozzle.
102. Lifter Tube.
103. Forcer Steam Nozzle.
104. Forcer Combining Tube.
105. Regulating Valve Spindle.
Rubber Wheel for 105.
Back Plate for 105.
Brass Washer for 105.
Screw for 105.
106. Connecting Rod.
Spring for 106.
108. Overflow Nozzle.
111. Line Check Valve.
Case for 111.
Cage for 111.
113. Brazing Nipple for Steam Connection.
Brazing Nipple for Suction Connection.
Brazing Nipple for Delivery Connection.
Brazing Nipple for Overflow Connection.
Threaded Nipple for Steam Connection.
Threaded Nipple for Suction Connection.
Threaded Nipple for Delivery Connection.
Threaded Nipple for Overflow Connection.
114. Coupling Nut for Steam Connection.
Coupling Nut for Suction Connection.
Coupling Nut for Delivery Connection.
Coupling Nut for Overflow Connection.
115. Connecting Link for Final Overflow Valve.
Steel Pin for 115.
Tobin Bronze Bolt for 115.
Tobin Bronze Nut for Bolt for 115.
117. Final Overflow Valve Stem.
Disc for 117.
Nut for 117.
118. Bonnet for Final Overflow Valve.
119. Packing Nut for Final Overflow Valve.
120. Bonnet for Intermediate Overflow Valve.
Tobin Bronze Cap Screw for 120.
Iron Washer for 120.
121. Intermediate Overflow Valve.
122. Holder for Overflow Valve Crank.
123. Adjusting Ring.
124. Bonnet for Regulating Valve.
125. Packing Nut for Regulating Valve.
126. Forcer Steam Valve.
Coupling Nut for 126.
127. Bonnet for Steam Valve.
128. Packing Nut for Steam Valve.
130. Lifter Steam Valve.
131. Tobin Bronze Stud for Connecting Rod.
132. Tobin Bronze Stud for 122 and 133.
Tobin Bronze Nuts for 122 and 133.
133. Crank for Overflow Valve.
134. Side Strap—right hand.
Side Strap—left hand.
Tobin Bronze Bolt for 134.
Tobin Bronze Nuts for Bolt fo. 134.
137. Lever.
Wood Handle for 137.
Screw for 137.
145. Tobin Bronze Pin Connecting 137 and 146.
146. Steam Valve Stem.

mediate overflow valve 121 and open the intermediate or line check valve 111.

The final overflow valve 117 will be closed and the inspirator in full operation when the lever is drawn back to the stop. When the pin in the wheel of the regulating valve is at the top, the inspirator will deliver its maximum quantity of water; to reduce the feed, turn the regulating wheel to the right.

To use the heater attachment lift the connecting rod until disengaged from the stud in the lever, then draw back the connecting rod to close the overflow valve. Regulate the quantity of steam by the lever without throttling the main steam valve on the boiler.

If the inspirator "breaks" or will not start promptly, see if there is a leak in the suction connections. If the openings into the tank are too small, or the hose strainer clogged, or the hose kinked or its lining collapsed, the inspirator will not get a sufficient supply of water.

If the inspirator will lift the water, but will not deliver it into the boiler, see that the main (boiler) check valve is in proper working order. If the opening in the main steam valve or its connections is not of the required size or there is a leak in the dry pipe, the supply of steam will be insufficient.

If the overflow pipe is smaller than the overflow nozzle there will be back-pressure, which will interfere with the proper working of the inspirator.

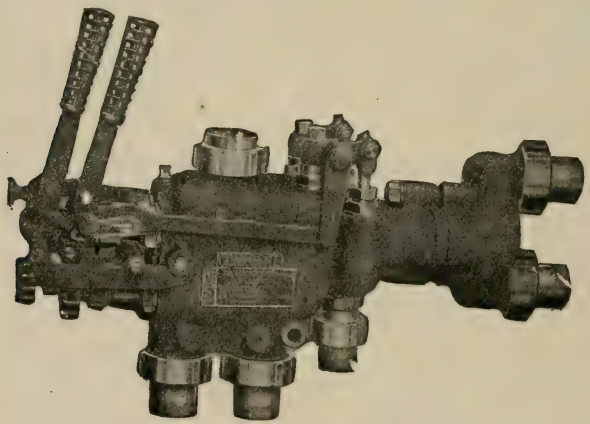
Injectors sometimes fail to operate when the water is low in the tank, but an inspirator will continue to operate when properly supplied with steam and water, and will not "break" unless the water is taken from the

suction. An engineer will quickly know by the sound when an inspirator "breaks."

THE HANCOCK "COMPOSITE" LOCOMOTIVE INSPIRATOR.

The "composite" is a compound Hancock inspirator, consisting of two separate and individual inspirators within one body, which can be operated separately or simultaneously, as desired.

Each and every part of a "composite" type inspirator that is subject to wear and renewal is identical in



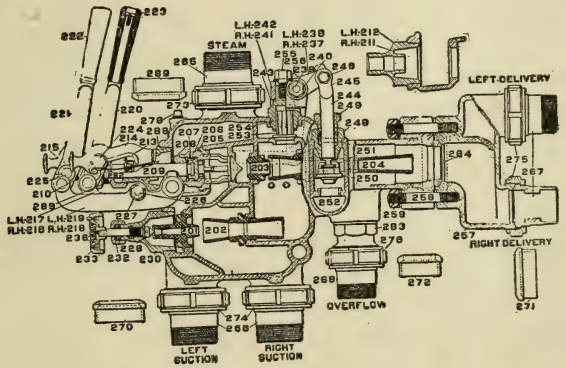
Hancock Composite Type Inspirator

design and interchangeable with the corresponding part of the standard locomotive inspirator of the same size.

This instrument enables two inspirators to be connected with practically the expense of connecting one, thus giving two independent ways of feeding the

boiler. By making practice of operating one instrument one time, and the other the next, both are constantly kept in perfect working order. The "composite" takes up practically no more room than a single instrument.

Where it may be desired to locate both injectors on one side of the locomotive convenient to either the engineer or fireman who has charge of pumping the engine, or on the boiler butt available to both, the advantages of the "composite" are apparent.



Hancock Composite Type Inspirator

This instrument can be used and a steady feed kept when there is a great variation in the power used. With the various combinations of nozzles used it is possible to keep a steady feed when using but eighteen per cent. of the maximum horsepower of the boiler. For example, take the special size of the "composite," arranged with size 40 nozzles in one side and size 55 nozzles in the other; when

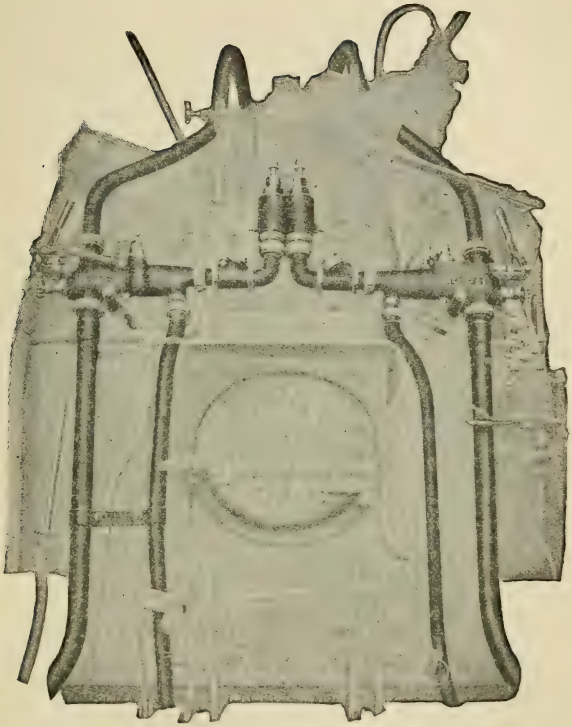
both instruments are working simultaneously the water delivered is sufficient to supply 1150 H. P. of boilers; by shutting off the size 55 inspirator, and reducing the feed of the size 40 inspirator steady feed for 200 H. P. can be maintained. Engineers will appreciate the advantages of this instrument where there is a great variation of power used.

By removing the delivery connection, which is joined to the body by a flanged joint, the forcing tubes of each inspirator are easily removed for cleaning or repair. The valve mechanism of each instrument is independent, the same as the Hancock inspirator, previously shown. The capacity of each inspirator can be regulated by the regulator. The minimum capacity is obtained by using the smaller inspirator with reduced feed. The maximum capacity by working both inspirators full.

Operation.—The Hancock "composite" inspirator is operated the same as the Hancock inspirator, type "A."

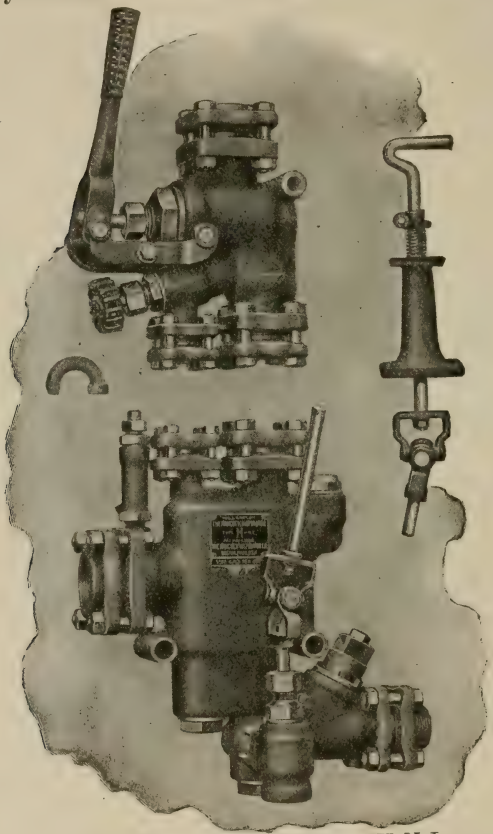
When it is desired to use both inspirators at the same time, start one, and after it is going start the other.

The arrangement of the different connections to the "composite" inspirator are somewhat varied. All have one each steam and overflow connections and a double suction connection—one to the left and the other to the right tank valve. The delivery connections can be combined, as shown in Fig. 10, to feed through a single boiler check, or entirely separate, supplying the boiler independently through each boiler check.



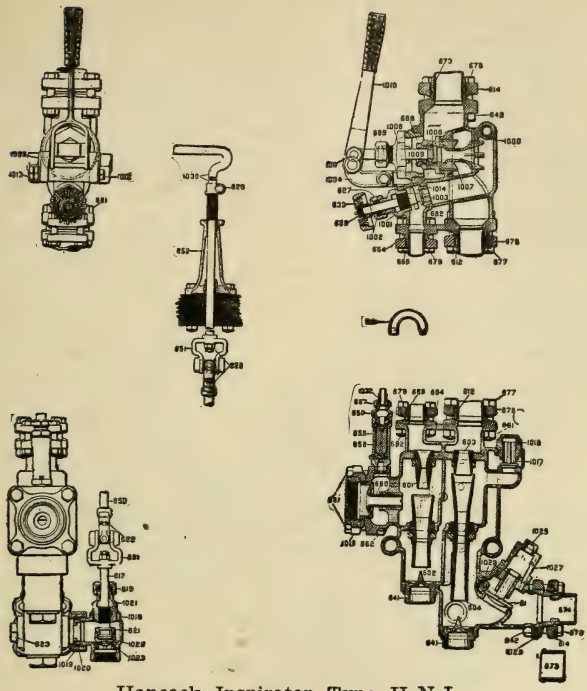
Application of Two Single Inspirators

The Hancock inspirator, type H-N-L, is a non-lifting inspirator, having the same double tube and positively closed overflow construction as have the



The Hancock Inspirator Type H-N-L

lifting types. It works without change of tubes or adjustment at all steam pressures from 30 to 350 pounds. Minimum capacity at 200 pounds pressure, 3 per cent. of maximum given.



Hancock Inspirator Type H-N-L

LIST OF PARTS

601 Lifter Steam Nozzle
602 Lifter Tube
603 Forcer Steam Nozzle
604 Forcer Tube
612 Brazing Nipple Forcer Steam
1018 Body for Overflow Valve
1019 Coupling for Overflow Valve
1020 Threaded Nipple for Overflow Valve
1021 Bonnet for Overflow Valve
1022 Disc for Overflow Valve
1023 Removable Seat for Overflow Valve
617 Stem for Overflow Valve
619 Packing Nut for Overflow Valve
621 Disc Nut for Overflow Valve
622 Nut for No.. 617 and 650
623 Plug for Overflow Valve
626 Collar for No. 1030
641 Cap for Combining Tubes
642 Nut for No. 678
1030 Handle for Overflow Valve
650 Extension Rod for Overflow Valve, each
651 Universal Joint, each
652 Running Board Stand
655 Alarm Valve Disc
656 Alarm Valve Body
657 Alarm Valve Bonnet
1031 Alarm Valve Nozzle
1015 Threaded Flange for Suction
660 Valve for Suction
661 Bolt for No. 1015
662 Nut for No. 661
664 Flange for Regulating Line Connection

665 Brazing Nipple for Regulating Line Connection
667 Coupling for Alarm Valve
1032 Brazing Nipple for Alarm Valve
673 Brazing Nipple for Delivery
674 Threaded Nipple for Delivery
676 Flange for Forcer Steam
677 Bolt for No. 676
678 Bolt for Nos. 614 and 1029
679 Bolt for No. 664
681 Nut for No. 677
682 Nut for No. 679
1016 Intermediate Overflow Bonnet
1017 Intermediate Overflow Valve
1027 Check Valve Cap
1025 Check Valve Regrinding Plug
91 Check Valve Disc
1029 Threaded Flange for Delivery
614 Companion Flange for Delivery
Name Plate
Capacity Plate
Name Plate Screws
Capacity Plate Screws
612 Brazing Nipple for Steam Connection
1001 Bonnet for Regulating Valve
614 Flange for Main Steam Connection
627 Packing Nut for Regulating Valve
1002 Stem for Regulating Valve
1003 Disc for Regulating Valve
629 Nut for No. 1002
1014 Removable Seat for Regulating Valve
633 Wheel for Regulating Valve
642 Nut for No. 678
1004 Right-hand Side Strap
1005 Left-hand Side Strap
664 Flange for Regulating Valve
665 Brazing Nipple for Regulating Valve
673 Brazing Nipple for Main Steam Connection
676 Flange for Steam Connection
677 Bolt for No. 676
678 Bolt for No. 614
679 Bolt for No. 664
681 Nut for No. 677
682 Nut for No. 679
1006 Operating Valve Bonnet
685 Operating Valve Packing Nut
1007 Valve for Operating Valve
1008 Auxiliary Disc for Operating Valve
688 Disc Nut for No. 1007
1009 Stem for Operating Valve
1010 Lever
1011 Lever Pin
1012 Side Strap Bolt
1013 Side Strap Bolt Check Nut

THE LUNKENHEIMER LOCOMOTIVE INJECTOR.

The Lunkenheimer '99 model standard injector is claimed by the manufacturers to be especially suitable for high-pressure work. The machine is of the double tube positive closing overflow type, but the lifting and forcing tubes are all in one line, and, in this respect, it differs in construction from the Metropolitan, Hancock and other machines, where the lifting tubes are situated below the forcing set.

This injector also differs in several other particulars; for instance, the regulation of the water discharge is accomplished in a different manner from any other injector. In the Lunkenheimer injector the amount of steam required to lift the forcing water is reduced in direct proportion to the amount of water

discharged. In other forms of injectors the amount of forcing steam remains constant, while only the lifting steam and water are decreased. The effect of this reduction of all three items in proportion results in causing the discharge to be cooler at minimum than in other injectors of this class.

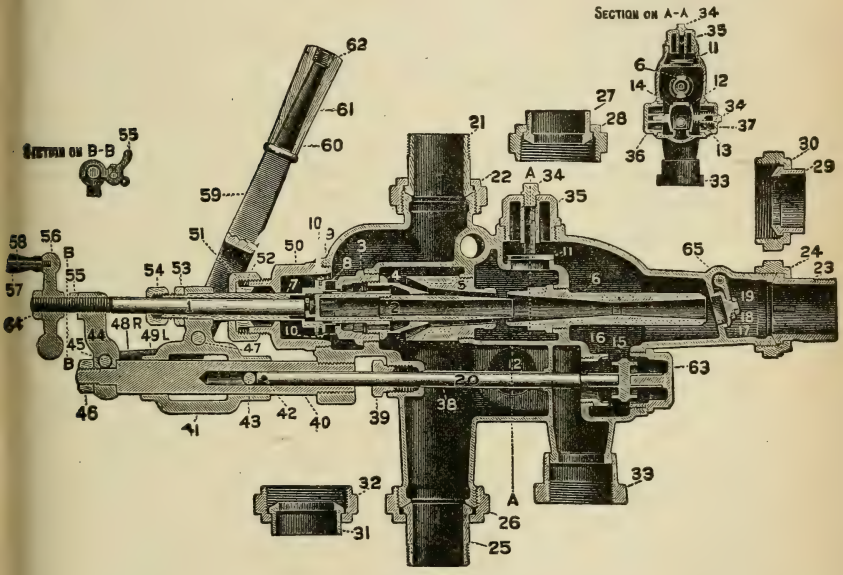


FIG. 11.

Lunkenheimer "'99" Model Injector.

The grading, as described in detail below, is accomplished by moving the steam tube (2) in and out by means of the crank handle (56) situated at the back end of the machine.

Mode of Action.—In starting, lever (59) is drawn

back slightly. This movement draws the steam valve (7) back and unseats same partially, which admits the lifting steam through passages in cap (3) and huddler (4), out around steam tube (2), into the water lifting tube (5), opening valve (11) and exhausting partially through the valve (4) and also through the tube (6) and out through overflow valve (15) into the atmosphere. The steam thus exhausted exerts a strong draught in the suction branch, discharges the air, and the water is "lifted." When water appears at the overflow, lever (59) is drawn all the way back. This movement uncovers the ports in the movable steam tube, admitting the jet of forcing steam, which drives the water through the forcer combining tube (6). By the same movement of the lever (59) the rod (20) is withdrawn and valve (15) is seated by the increasing pressure in the delivery chamber. Valve (11) is also seated by the pressure on top of same, and all water is forced through the tube (6), overcomes the boiler pressure on line check valve (17) and passes into the feed pipe. The amount of water delivered is regulated by the movable steam tube (2). This tube moves longitudinally through the other tubes in the machine and is actuated by the threaded stem (1) and crank (56). To deliver the maximum amount of water the tube is withdrawn to its limit. This admits the maximum amount of steam around the outside of the tube to lift the water, and also to the interior of same to force the jet of water into the boiler. The withdrawal of tube (2) also increases the passageway around same and through tubes (5 and 6). When it is desired to reduce the capacity, the crank (56) is turned from left to right, which forces the tube (2)

into the openings in tubes (4, 5 and 6). The effect of this is :

First. To cut off the amount of forcing steam passing through the ports in the end of tube (2) as same is moved into the tubular extension of huddler (4).

Secondly. It decreases the passage of lifting steam around tube (2) and through huddler (4), due to the tapering diameter of tube (2) approaching the fixed internal diameter of huddler (4).

Thirdly. The passage ways through tubes (5 and 6) are decreased as the tube (2) is passed into same.

The amount of steam required is decreased proportionately to the quantity of water discharged. In other injectors the discharge of steam remains constant, while the water alone is decreased in quantity. The result of this method is that this injector delivers water, when working at minimum, at a low temperature. As scale only forms when water is heated to high temperatures, there is less liability of trouble from this cause than with machines where the discharge is very hot.

The auxiliary water valve (12) is situated at the side of the machine and controls the port between the suction branch and the intermediate chamber of the injector, see sectional cut. The function of this valve is to make the injector self-adjusting and unaffected by variations of steam pressure. At certain pressures the water lifting tube does not deliver a sufficient quantity of water to condense the steam, and at such times the vacuum formed in the chamber causes the valve (12) to open and admit the additional amount of water required.

This machine is claimed to be very economical and

efficient, and will work at all pressures from seventy to two hundred and fifty pounds without any adjustment whatever.

THE OHIO LOCOMOTIVE INJECTOR.

The Ohio injector is noted for its simplicity, having few parts and those arranged conveniently for repairs. It will be noted from the sectional view here shown

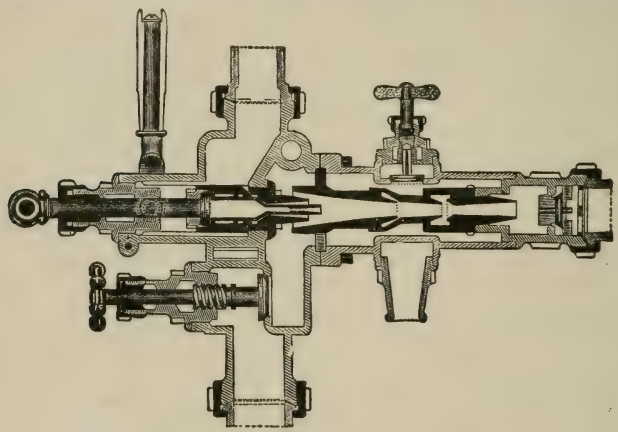


FIG. 12.
The Ohio Locomotive Injector.
(Sectional View).

that the combining tube and the delivery tube are screwed directly to the delivery end connection on the right in the cut, and can be taken out with an ordinary wrench without disturbing the other tubes; the lifting tube, instead of being screwed to the injector body, is held in place between the two flanges which are bolted together, as shown. This design lessens the liability of marring or breaking the tubes in their removal for inspection or repairs.

This injector is interchangeable with the other principal injectors used, the size and location of its connections being the same.

"LITTLE GIANT" LOCOMOTIVE INJECTOR.

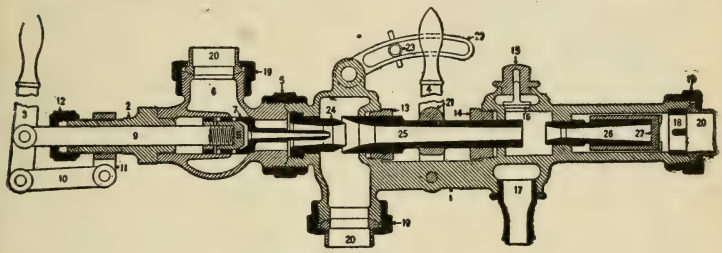


FIG. 14.
Little Giant Locomotive Injector.
(Sectional View.)

LIST OF PARTS.

1. Body.
2. Stuffing Box.
3. Starting Lever.
4. Injector Lever.
5. Right and Left Nut.
6. Starting Valve Body.
7. Main Valve.
8. Jet Valve.
9. Jet Valve Stem.
10. Starting Valve Link.
11. Fulcrum.
12. Stuffing Box Nut.
13. Large Packing Nut.
14. Small Packing Nut
15. Overflow Cap.
16. Overflow Valve.
17. Overflow Nozzle.
18. Check Valve Stop.
19. Coupling Nut.
20. Swivel.
21. Combining Tube Clamp.
22. Quadrant.
23. Thumb Screw.
24. Steam Tube.
25. Combining Tube.
26. Discharge Tube.
27. Check Valve.

This injector is fitted with a movable combining tube (part numbered 25 in sectional view) operated by a lever which allows it to be adjusted to work correctly at different pressures of steam and under the many conditions required of a locomotive injector.

To Operate.—Have the combining tube in position to allow sufficient quantity of water to condense the steam when the starting valve is full

open, then open the starting valve slightly; when water shows at the overflow, open full. Regulate the water by moving the combining tube—toward *A* for less water, and toward *B* for more water.

To Use as a Heater.—Close the overflow by moving the combining tube toward *B* until the tubes

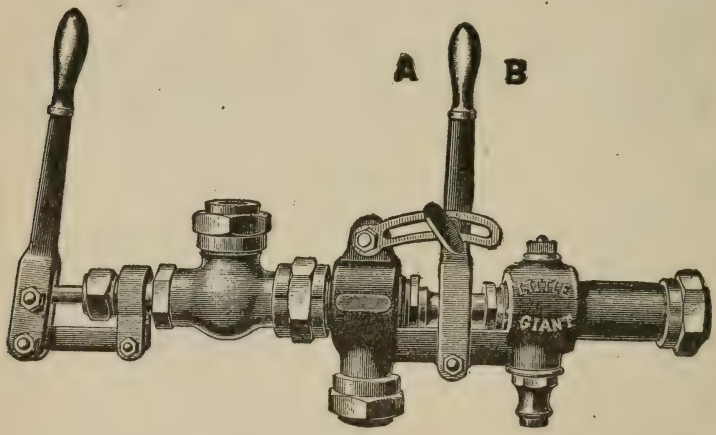


FIG. 15.
Little Giant Locomotive Injector

25 and 26 come together, then open the starting valve enough to admit the quantity of steam required.

"SWING" INTERMEDIATE OR LINE CHECK VALVE.

The check shown in the accompanying engraving can be applied to the "branch" pipe or injector delivery pipe of any locomotive injector.

Experience has proved that a hinged or swinging movement of the valve is more reliable and its action more certain than either the horizontal or vertical types with a sliding movement, especially where trouble is caused by incrustation from limy or impure water.

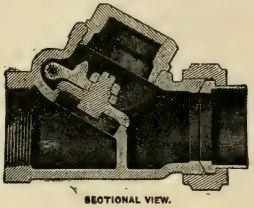


FIG. 1. Swing Intermediate or Line Check.

There are no wings or guides to become incrusted with scale or deposit while the valve is open and to prevent its closing, and the liability of damage or delay caused by the valve sticking or failing to close is obviated.

No matter how efficiently a boiler check is used, there is no question as to the double advantage gained by the use of a line check valve, and few modern equipped locomotives are now without them.

OIL CUP—FOR INJECTORS AND INSPIRATORS.

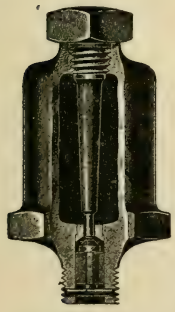


FIG. 1. Injector Oil Cup. (Sectional View.)

For lubricating the internal parts of any injector or inspirator it is very desirable to have a suitable oil cup, as shown in the engraving (Fig. 1), attached to the injector or steam pipe.

It is considered that the introduction of oil into the steam chamber is more effectual than its admission into the water chamber. Hence the oil cup should be arranged to discharge directly into the steam chamber, thereby lubricating the nozzles, tubes and other parts subject to wear, and preventing the adhesion of scale formed by impurities in the water.

When the filling plug is unscrewed sufficiently to allow the steam to escape, the valve in the bottom closes and the oil cup can be readily filled without closing the main steam valve. When the filling plug is again screwed into position the valve in the bottom is opened and the oil feeds out.

THE EJECTOR OR JET PUMP.

The "ejector" or jet pump is designed for use at railroad water stations, on construction trains, for emptying wheel pits and similar railroad service.

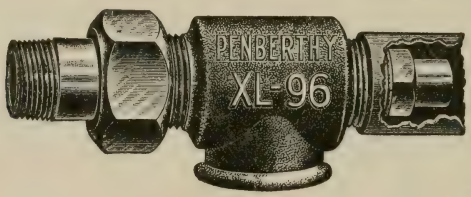


FIG. 1.
Penberthy Ejector.

It is a device, simple in construction, compact in form, convenient to handle, has no movable parts and cannot get out of order.

Fig. 2 shows the position in which an ejector should be placed for high elevations. For lifting only the ejector can be placed at the boiler level.

Where it is required to lift water ten feet or over it is advisable to place a foot-valve on the lower end of the suction pipe.

All ejectors, if properly constructed, will lift water to a height of twenty-five feet, but for elevating

over twenty-five feet the ejector should be placed near the water level and a delivery pipe one size larger than the connections used. In this man-

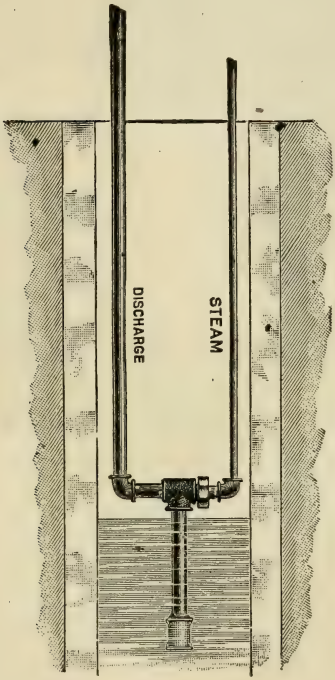


FIG. 2.

Ejector, showing connections for Elevating.

ner water can be lifted about fifty feet with seventy-five pounds steam pressure, and about seventy feet with one hundred pounds steam pressure.

Fig. 3 is a general view of the Hancock ejector. The "steam," "suction" and "delivery" connections are as illustrated.

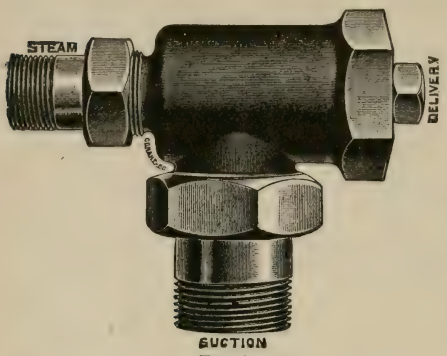


FIG. 3.
Hancock Ejector or Jet Pump.

The suction connections must be perfectly tight. Before operating the ejector blow out the steam pipe to remove any iron chips, red lead, etc.

To use an ejector economically, regulate the quantity of steam with the starting valve.

This ejector is furnished to operate with either steam, air or water.

LOCOMOTIVE BOILER CHECKS.

Too great care and attention cannot be given this important part of the locomotive.*

Leaky boiler checks are always a source of great annoyance and no injector, no matter how good it may be, will give satisfactory service under these conditions. The check valve must have sufficient "lift," that is, be allowed to raise sufficient distance from its seat, and when the injector is shut off the check valve must close; if it does not, but sticks or cocks to one side, the steam from the boiler has a tendency to blow back through the injector and cause the latter to become heated beyond its proper working condition, and also causes the injector and branch pipe to become incrusted with lime or other deposits.

The object of the boiler check is to prevent a return flow of water from the boiler when the injector is shut off; the valve is automatically closed by the pressure from the boiler acting upon its upper surface.

Fig. 1 gives three views of a commonly used locomotive boiler check valve, the casing being made of heavy cast iron; the advantage of this form of casing is that any ordinary amount of pounding and rapping that usually occurs when a check "sticks up" will not spring the body and cage of the check and thereby render the valve inoperative.

* For the location of the locomotive boiler check, see the chart "American Type Locomotive," parts numbered 120 and 121.

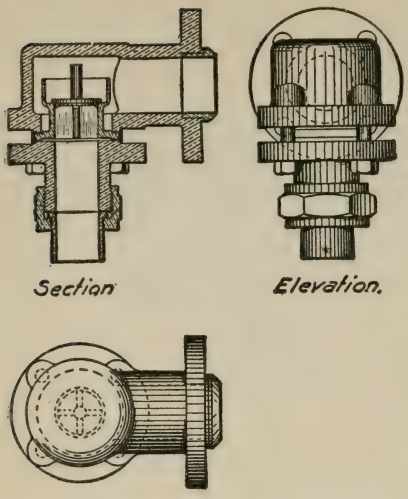


FIG. 1.
Boiler Check Valve, with Cast Iron Casing.

depends a great deal upon the size of both check and injector, but should not be less than one-fourth of an inch nor rarely over three-eighths of an inch.

A combined main boiler check and stop valve is shown in Fig. 2.

The main check valve and its seat can be removed for grinding or repair while the boiler is under steam. This is often of great advantage when a railroad is taxed

The check valve itself is generally but a small part of the boiler check, as the whole attachment is termed. Most check valves have three or four lugs or "wings" which extend below the valve seat and serve as guides to the proper re-seating of the valve.

The proper "lift," that is, the amount the valve can raise, to give a boiler check

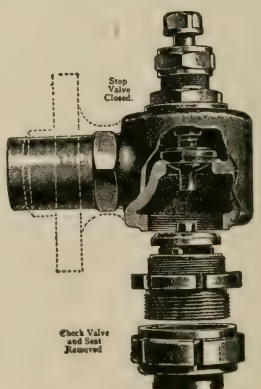


FIG. 2.
Sellers' Combined Boiler Check and Stop Valve.

to the limit for locomotives and often effects a saving of several hours. The illustration shows the stop valve (which is adjusted from the top outside) closed, and the check valve and seat removed. When the check valve is replaced it is evident its lift can be regulated by the amount the stop valve is raised.

Fig. 3 shows a double combined boiler check and stop valve which is provided with removable seats and a stop for each check valve, so that if either one of the check valves fail it may be "cut out," without interfering with the feeding of the boiler.

This valve is provided with hubs on the body, between stop valve and check valve, for inserting an independent drain valve, and may be applied to the side or back head of the boiler.

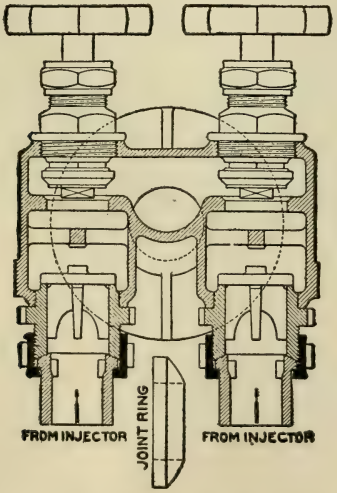


Fig. 3. Nathan Double Boiler Check Valve.

With the boiler check shown in Fig. 4, the rotary movement of the seat while closing (by the effort of the inclined turbine wings under the seat) on passage of fluid, makes a clean and sure closing check. This may be used with or without an adjustable top, shown at the left of the stem, which allows the volume of passage to be varied, and thereby proves valuable for very careful adjustment in the working of injectors.

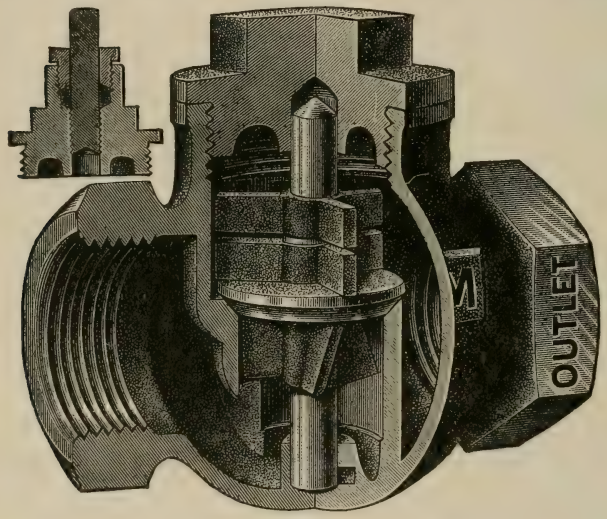
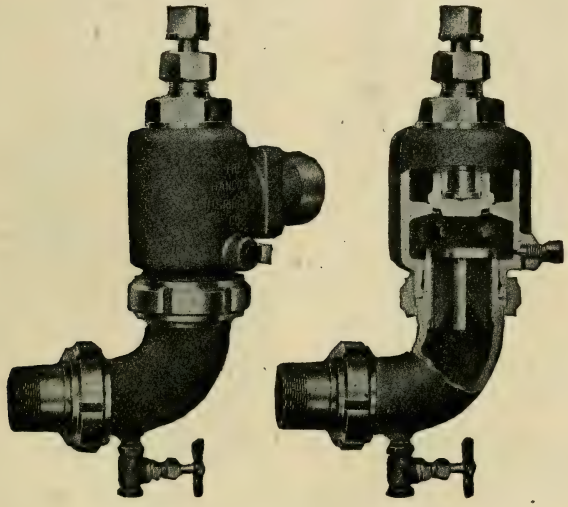


FIG. 4.
Müller Turbine Boiler Check Valve.

The rotary seat insures an even wear and long life, and the mode of passage of fluids insures a clean valve at all times.

HANCOCK BOILER CHECK VALVES

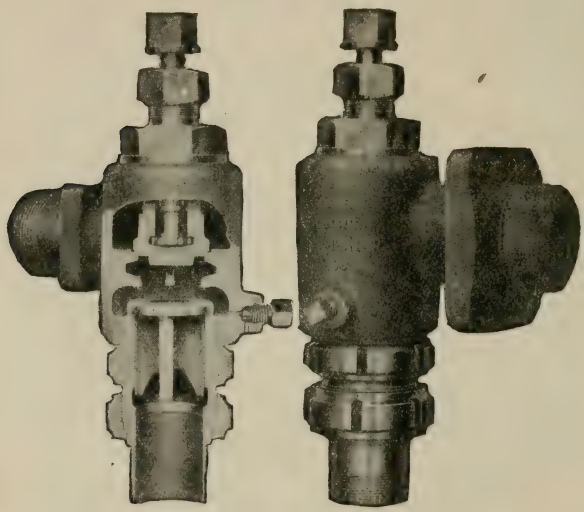
These boiler check valves are made for a large variety of applications; bottom or side inlet, single or double patterns, with and without stop valves; also with flanged couplings held together with bolts instead of the usual screw thread and "spanner" nut. The valve itself, however, is of but two types. In one, the disc is guided by short wings below the seat and by a stem extension above which slides in a cap. By unscrew-



Hancock Vertical Check Valve

ing the cap in this design, the valve may be inspected or reground while in place without removing the valve body or disconnecting its piping. In the other type, the valve is guided by long wings below the seat and has no stem above. The seat is removable from the valve body by disconnecting a union which makes it possible to readily remove both seat and valve for regrinding.

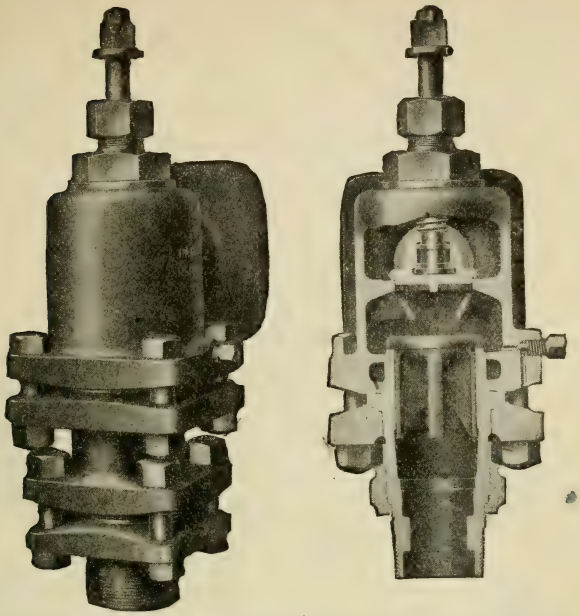
The Hancock boiler check valves are convenient where both injectors are on one side of the locomotive and especially so for backhead applications. The threaded joint ring of this valve affords a neat and desirable method of attaching to delivery pipe. The square flange construction and special types of connection joints are noticeable features of the larger valves.



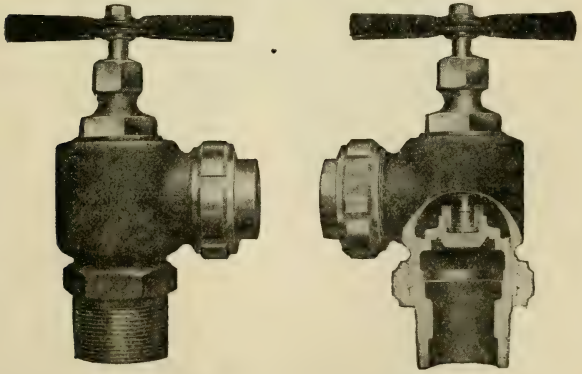
Hancock Vertical Check Valve with Stop Valve—Screw Connections

In the combined stop and check types, by closing the stop valve the checks may be easily removed while the engine is under steam or a leaking check may be temporarily closed off while on the road.

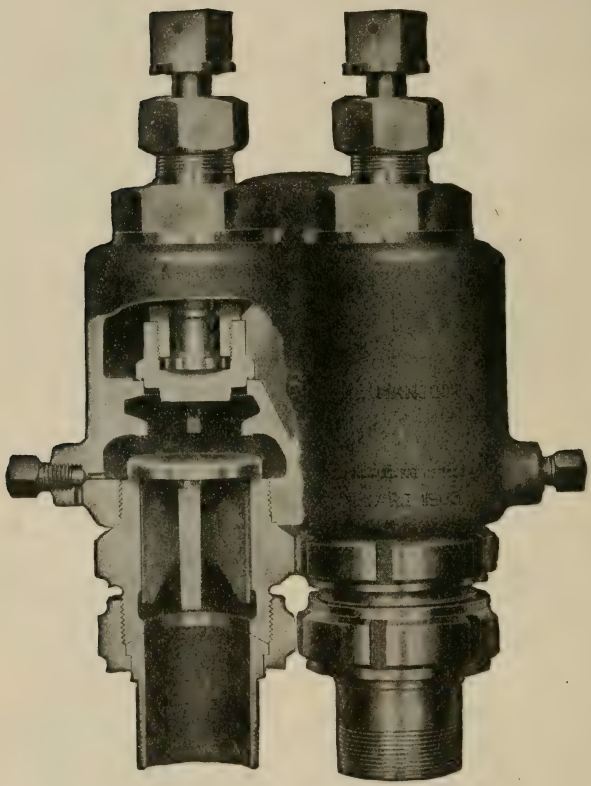
The Hancock main steam valves have exceptionally full sectional areas in the bodies. They have solid or union shanks of flanges, threaded or brazing nipples for the outlets and are made in angle, straightway or 60-degree patterns.



Hancock Vertical Check Valve with Stop Valve—Flanged Connections



Hancock Main Steam Valve for Injectors or Inspirators

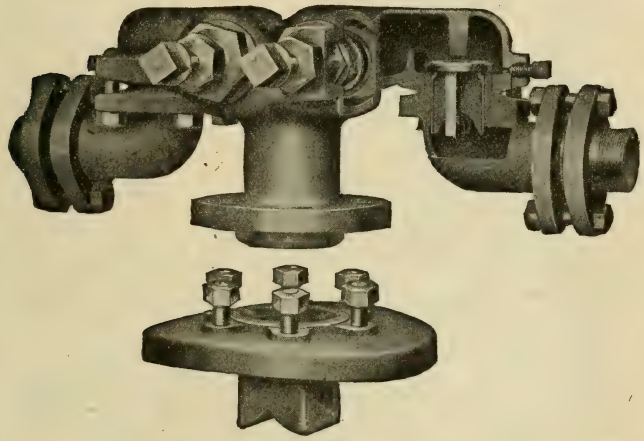


Hancock Double Vertical Check Valve with Double Stop Valve

THE HANCOCK DOUBLE VERTICAL CHECK VALVE

This Hancock double vertical check valve, with double stop valve is so designed as to enable it to be mounted on top of the boiler.

The construction and operation of the valve are clearly displayed in the cut. Two independent systems feed the water directly into the steam space of the boiler and either side may be cut out without interfering with the continuous feed. The feed water enters the valve through the quarter turn



Hancock Double Vertical Check Valve

connection which forms a seat for the check and a guide for its wings.

This connection is bolted to the main body of the valve and to the feed line, permitting of quick repairs and replacements. Various refinements of the design insure long life and dependability.

The complete valve is secured to the boiler by a boiler flange and studs, a joint ring having a flat seat on one side and a ball joint on the other being provided to secure steam tight joints. The boiler flange, which conforms to the curva-

ture of the boiler, is provided with a deflector which directs the flow of the feed water towards the sides of the boiler, preventing a direct discharge on the dry pipe and upper tubes.

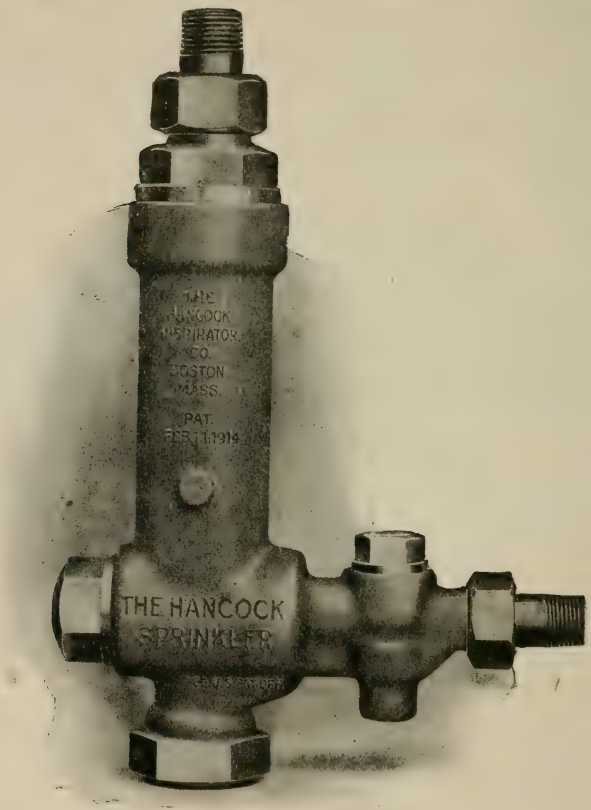


Fig. 1—Hancock Coal Sprinkler

HANCOCK COAL SPRINKLER

Many of the accidents in a locomotive cab are due to the failure of the apparatus for sprinkling. Water for sprinkling

the coal is usually taken from the delivery pipe of the injector, and the temperature is so high and the pressure so great that when the delivery hose becomes clogged, as it frequently does on account of the heat and pressure, the hose either bursts or is blown off the connection, scalding the occupants of the cab.

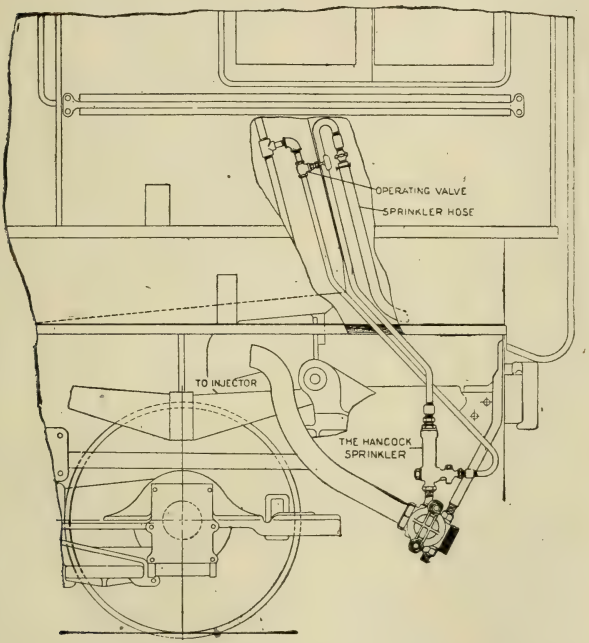


Fig. 2—Hancock Coal Sprinkler—Showing Its Application on a Locomotive

The Hancock coal sprinkler is an apparatus so designed that it is proof against accidents of this kind. If the delivery of water is interrupted or the injector refuses to work the apparatus instantly and automatically accomodates itself to

the new condition and the steam and hot water are carried off without danger to anyone.

The Hancock Coal Sprinkler acts on the principle of the injector. As shown in Fig. 2, it is generally applied to the strainer or on the suction pipe of the injector by the use of a short connecting nipple having a bend so that the sprinkler will be in a vertical position. The steam pipe should be as straight as possible and with no pockets or dips and should be so arranged that it will drain itself and thus prevent freezing. There should be a full supply of steam and a valve should be placed in this steam pipe at a point in the cab where it may be conveniently reached.

The delivery pipe should have as few bends as possible, with no pockets or dips, and this, too, should be so arranged that it will drain and thus prevents freezing. As large a nozzle as possible should be connected to the hose from this pipe.

In operating the coal sprinkler (See Fig. 3) the steam valve 7 is opened wide. That action closes the drip hole B. The piston on the lower portion of the guiding stem of this valve will cover this drip hole B when valve 7 is open. Steam will now flow through nozzle 4, forming a jet and combining with water in the combining tube 5.

Under proper working conditions, steam cannot flow further than steam nozzle 4, as this part and the combining tube 5 are always under water by reason of the location of sprinkler at a point lower than the tank. This will, of course, prevent steam entering the delivery pipe or hose under such conditions.

The water will flow into the pressure chamber A, and the discriminating valve 2, which has been heretofore closed, will be lifted. Port C, which has been open heretofore will now be closed by the lower end of valve 2 when it lifts, and the water will then be forced through the delivery pipe and into the delivery hose.

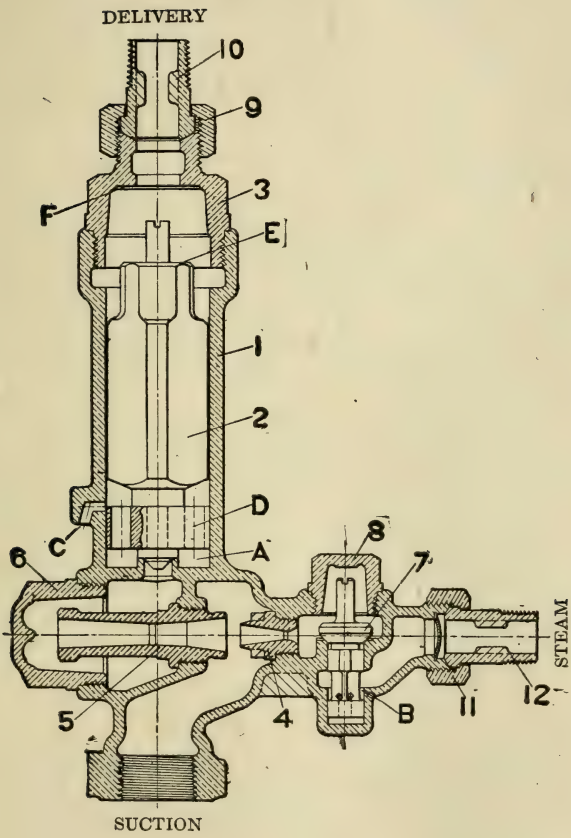


Fig. 3—Hancock Coal Sprinkler—Sectional View

The accidents resulting from the use of a sprinkler have generally been caused by an interruption of the water supply or the failure of the injector to work. Should the flow of water be interrupted or the injector fail to work, valve 2, owing to its peculiar construction by which it discriminates between steam and water, will automatically raise when steam enters chamber A, and form a seat at point F effectually closing the delivery end of the sprinkler and preventing steam from entering the delivery pipe and hose.

When not operating, both valves will automatically seat. The discriminating valve, No. 2, is of sufficient weight to prevent water flowing up the delivery pipe when steam is shut off. Any water in the delivery pipe or hose when the sprinkler is shut off, will flow out of drain hole C, which is automatically opened when valve 2 assumes its original position, as in Fig. 3. At the same time steam valve 7 will automatically seat, so that no water will flow up the steam pipe and all water or steam in the steam pipe will drain out at the hole B.

In the operation of the Hancock Coal Sprinkler even the inexperienced are in no danger of accidents. From the above description it will be seen that the apparatus is so arranged as to be operated entirely by opening or closing one valve — the steam valve in the cab; it meets and takes care of each of the conditions which are the common cause of accidents; and its construction is such that it also drains itself under all conditions, thus making its operation certain no matter what the temperature may be.

NATHAN COAL SPRINKLER

The purpose of this device is to furnish water under sufficient pressure for wetting down the locomotive deck and sprinkling the coal, but at a much lower temperature than that at the delivery of the ordinary boiler-feeding injector, thereby avoiding accidents to engineers and firemen.

DIRECTIONS: (1) Attach the sprinkler on a line with the top level of water in the tank, and never lower than about eight inches below that level.

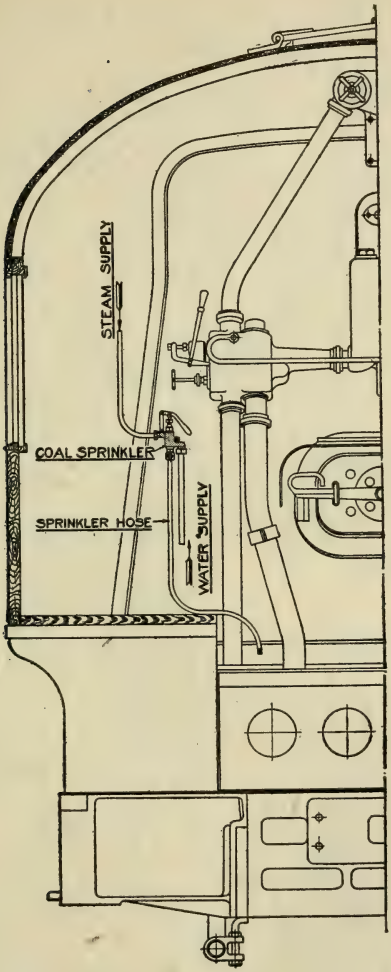


Figure 1

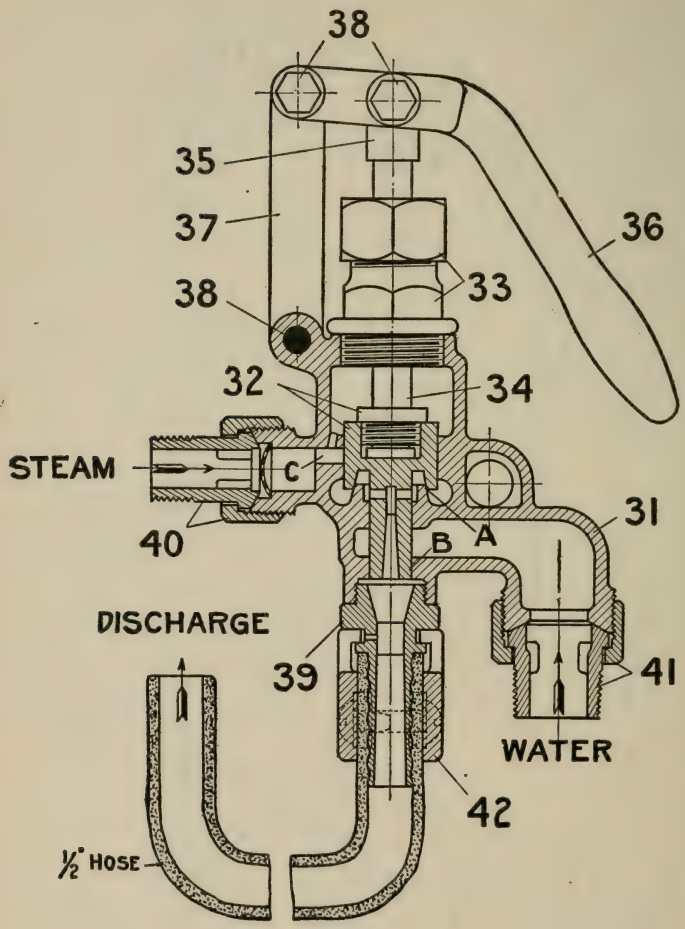

38
35
37
36
38
33
32
34
STEAM
C
40
31
B
A
DISCHARGE
39
41
WATER
42
½" HOSE

Figure 2

(2) Connect steam supply pipe to the boiler in the most convenient location with shut-off valve in pipe.

(3) Attach water supply pipe to injector water supply pipe in the most convenient manner.

(4) Attach the sprinkler hose to the sprinkler by means of the "neverslip" clamp, which is furnished with the instrument, as per Fig. 1.

(5) Place the hose discharge nozzle into the end of hose securely by wiring the hose tightly against it. See that the small opening in discharge nozzle opens outward.

(6) The steam valve of the sprinkler must be kept tight.

(7) Size of steam connection ½-inch iron pipe. Size of water connection ¾-inch pipe. Sizes of sprinkler hose ½-inch

SAFETY COAL SPRINKLER

NAMES AND NUMBERS OF PARTS

31. Body.
32. Steam Nozzle and Nut.
33. Bonnet and Nut.
34. Spindle.
35. Lever Link.
36. Lever.
37. Fulcrum Bar.
38. Bolt and Nut.
39. Delivery Nozzle.
40. Steam Connection.
41. Water Connection.
42. Never Slip Hose Clamp.

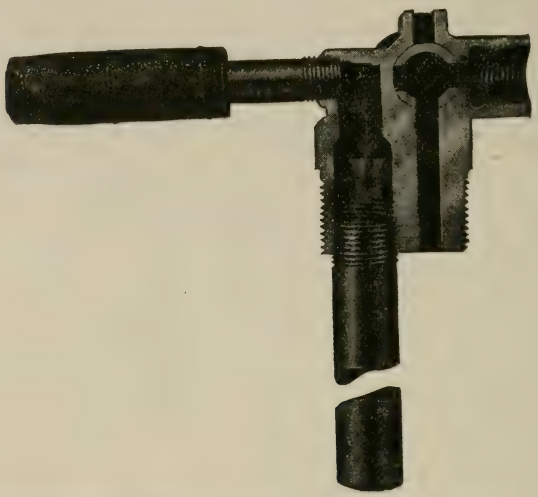
To Operate: Pull the lever out as far as it will go.

To Stop: Push the lever down as far as it will go.

"WATERTOWN" COAL SPRINKLER

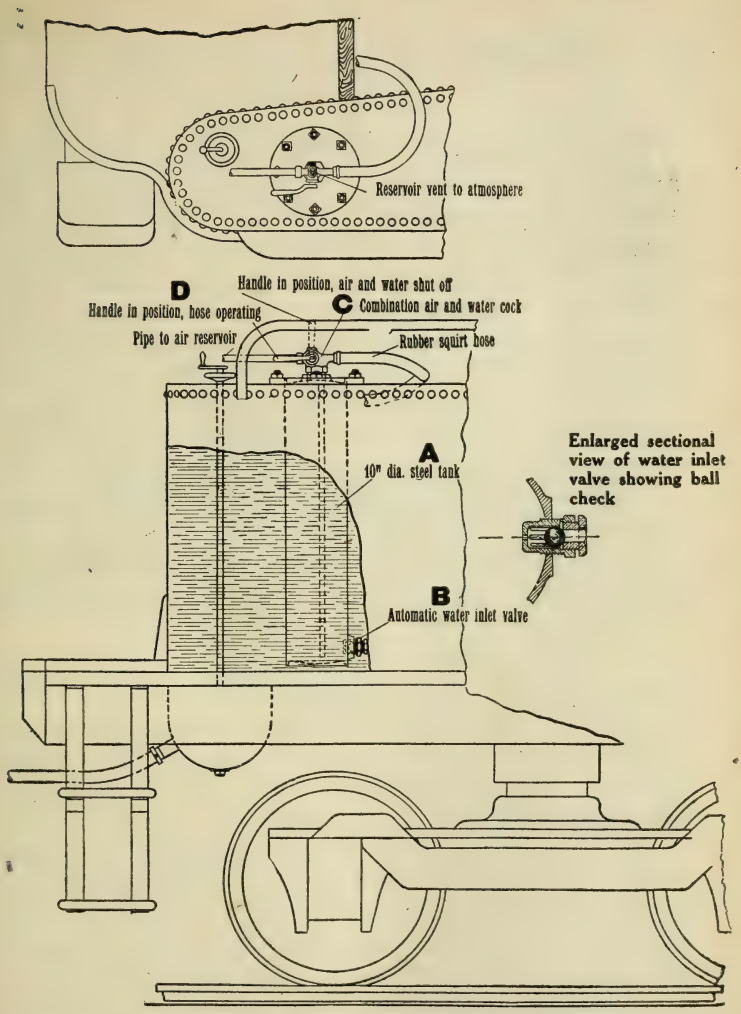
The Watertown safety squirt hose is designed to eliminate using hot water from the injector and takes in its place cold water from the tender. A cylindrical steel tank, 10″ in diameter, length depending upon height of tender, is let down into the tender through a hole cut in the water leg and is secured in place by bolts passing through a flange located at the top of the small tank. A specially designed small check valve located in the bottom of the tank allows water to enter it through the tender. The squirt hose is attached to a simple operating valve located in the top of the tank, and which is piped to an air reservoir. A three-way plug cock shown in small cut controls the complete operation of the apparatus;

in the non-operative position all air is shut off from the reservoir tank, which has a free vent to the atmosphere; as soon as the operating handle is thrown through a quarter turn the vent is closed, air is admitted to the reservoir which has previously filled with water through the automatic inlet valve,



Watertown Coal Sprinkler—Sectional View of Controlling Valve

which now closes due to the pressure of the air and at the same time this pressure forces water through a siphon nipple in the tank and out through the squirt hose. Shutting off the hose by means of the handle shuts off all air communication and vents the tank so that it at once fills automatically.



THE "WATERTOWN" SAFETY SQUIRT HOSE
Assembly View Showing Apparatus Installed in Forward End of Tender Near Strainer Valve

BOILER WASHING AND TESTING APPARATUS. *

The accompanying engraving shows a washing and testing apparatus, which will wash out, fill, and apply pressure to a boiler, with hot water. It has a capacity of 5,000 gallons per hour. When this apparatus is used, the boilers are washed much more effectually than can be done with cold water, and their temperature is not materially reduced, which is injurious to flues and fire-box. It enables one to blow out, wash and fill with hot water and have a locomotive ready for service within one hour, without injury to the boiler.

This apparatus has connection for 2-inch pipes, and must be located where the water will flow to it.

When applying pressure this apparatus will produce and maintain from three to five times the amount of steam pressure used in operating it.

To Attach.—Connect steam pipe to swivel No. 1; water supply No. 2, and discharge to No. 3.

To Wash Out Boiler.—Close overflow (*O*) by moving tube (*C*) over to the discharge. Open water supply, then steam valve (*A*). until the required force is obtained.

To Apply Pressure.—When boiler is filled with hot water, the same as when washing, shut steam valve (*A*); open overflow (*O*) by moving combining tube (*C*) to about midway of its travel; when water shows at overflow (*O*), open steam valve (*B*) slowly

*Strictly speaking, details of washing out arch tube and cleaning apparatus are not Locomotive Appliances, but their use in connection with the proper care of a locomotive is so important that they are included in this volume.

until full open; then adjust combining tube so as to allow the least quantity of water possible to show at (*O*). Relief valve (*R*) can be adjusted as desired.

Keeping the cock to the pressure gauge partly closed will prevent the hand from unduly vibrating.

One of the Many Ways It May Be Located, is so to take cold water to the apparatus from, and put hot water back into the pipe that supplies water for

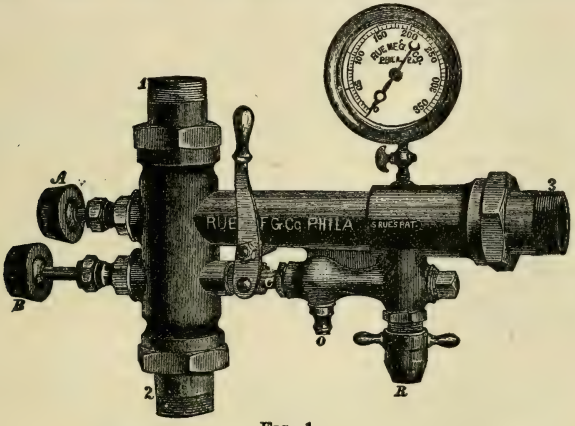


FIG. 1.
Boiler Washing and Testing Apparatus.

washing with cold water—always putting in a stop valve or cock between the connections. The hot water from the apparatus will pass with great force through the same pipe, hose, nozzles, etc., as are used with cold water.

HOT WATER WASHOUT PLANTS

A general description of what constitutes a hot water boiler washing and boiler filling apparatus, and some of the principal functions and advantages.

A boiler washout and filling apparatus consist of heaters, tanks, pumps, valves, temperature regulators, etc., intended to provide hot water with which to wash out locomotive boilers and to refill them after washing. The water is heated in part by the blow-off products from the locomotive supplemented by exhaust steam and occasionally by live steam. The temperature of the washout water is maintained at approximately 130 degrees and the water for refilling at 180 degrees or above. The heat control is automatic, the apparatus provides for locomotives blowing off into the system, thus keeping the engine house free from noise and fog. The Lot water treatment insures quicker and better cleaning, the time of blowing off is shortened, the time of steaming up is materially shortened and considerable coal saved; damage to boilers is very materially reduced, and the total time of turning an engine is reduced by at least 50 per cent. There are two types of apparatus, one the closed heater, pressure type, in which the water is heated as it passes through the heaters; and the other the open heater and non-pressure tank system in which the water is first heated and then stored.

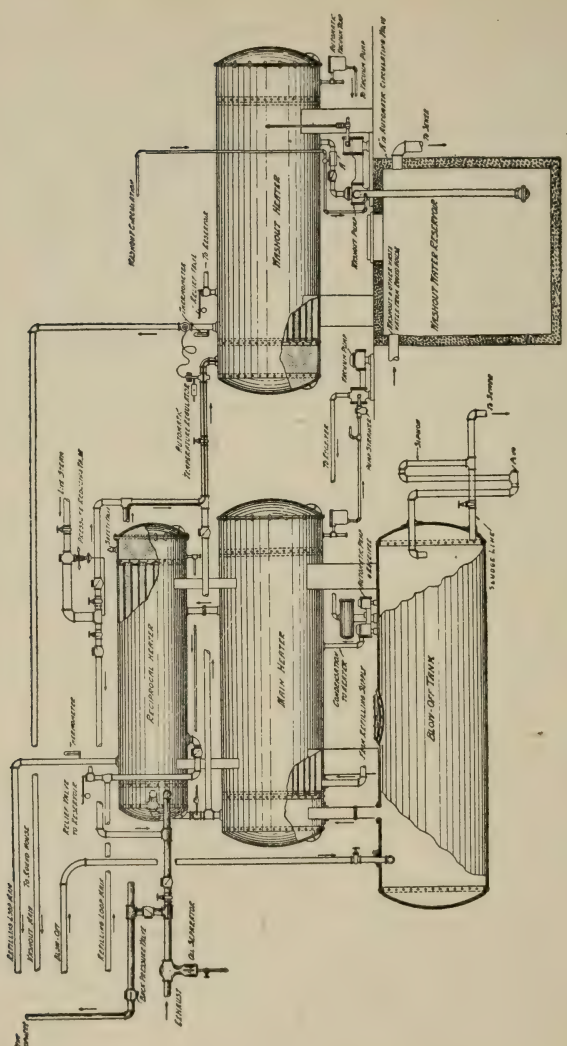
OPERATIONS OF A COWLES-MacDOWELL BOILER WASHING AND FILLING SYSTEM.

Blow-off water and steam pass first into the blow-off tank, from this tank the steam passes to the first end compartment of the main heater, then through the tubes to the opposite end compartment of the main heater. Condensation, resulting from the steam imparting its heat to the refilling water surrounding the tubes, is discharged into the main heater, where it adds to the quantity and heat of the refilling water. Clean water for refilling is taken from the railroad company's supply, passed through the main heater, where its temperature is raised by the blow-off steam; from the main heater the refilling water passes to the reciprocal heater, where its temperature

is raised to 180 degrees and above, and then goes to the roundhouse. The heat for raising the temperature of refilling water in the reciprocal heater is that from the exhaust steam principally, supplemented by the surplus blow-off steam and by live steam at times when there would be a deficiency of exhaust and blow-off steam (the live steam reducing valve is set at 1½ lbs. generally). Steam enters one end compartment of the reciprocal heater, passes through the tubes and imparts its heat to the refilling water surrounding the tubes and is condensed and discharges into the other end compartment of the reciprocal heater and from there it is conveyed to the main heater, adding an additional amount to the quantity and heat of the refilling water. From the end of the refilling line there is a return line to the reciprocal heater which completes the loop for circulation; or when a separate refilling pump is installed circulation is maintained through the Automatic circulating valve on pump.

Blow-off products are held in the blow-off tank, where the heat is extracted under a vacuum in the form of a vapor, which passes into the main heater, as described above, after which the dirty water passes to the sewer through the siphon in the valve pit, the sludge can be washed to the sewer through a sludge pipe in the bottom of the tank, or removed through a manhole. The objects of the siphon are to seal the tank for insuring a vacuum therein and for discharging only the dirty water to the sewer.

The washout pump takes its supply from the washout reservoir, or from the general water supply when a reservoir is not installed, and passes in through the washout heater, where its temperature is raised by the heat from exhaust steam, surplus blow-off steam and live steam which circulate through the tubes in the heater. Live steam is used only when there is a deficiency in the other heat supplies. The temperature of the washout water is maintained at about 130 degrees by means of a special automatic temperature regulator. Circulation is maintained through the automatic circulating valve on the pump. The water used for washing out returns to the washout reservoir. The vacuum pump maintains a vacuum in the tubes and end chambers of the washout



Cowles-MacDowell Boiler Washing and Filling System

heater which insures efficient circulation of steam through same. The condensation from the washout heater is discharged into the main heater.

The vacuum pump maintains a vacuum in the end compartments and tubes of the main heater, the bloff-off tank, and the blow-off main to the valves on the lower ends of the post drops. While the vacuum in the blow-off main is destroyed when engines blow off, the back pressure against the blow-off steam and water is practically destroyed by the counter effect of the vacuum, thus insuring material reduction in the time of blowing off, particularly at the later end of blowing off when the steam pressure is low. The vacuum is the means by which the blow-off steam is passed into the heaters. The vacuum pump discharges all condensation into an automatic pump and receiver, which discharges into the main heater.

Globe, check, pressure relief, and other valves are set in the pipe lines for the usual purposes, and a vent pipe with a back pressure valve set at about 5 lbs. leads to the atmosphere and constitutes the main relief or safety valve. The pumps are controlled by governors in the usual way. The heaters are built for 135 lbs. working pressure.

The plant is practically automatic in operation and constitutes a continuous feed water heating system.

NATIONAL BOILER WASHING SYSTEM.

The National Boiler Washing System is designed to wash and refill locomotives with hot water. This hot water is obtained by saving the heat units which are in the locomotive when it arrives at the roundhouse.

The hot water contained in the locomotive boiler is removed and stored in a steel reservoir and used when wanted for washing purposes. The steam from the locomotive is condensed by fresh cold water in such a manner that the cold water is heated by the steam and the resulting hot water stored for use as refilling water. These results are obtained by piping the roundhouse with a series of mains which have convenient drop pipes located near the locomotives. These

mains lead to a system of tanks, pumps and heaters where the water and steam is mingled and stored. The method of operation is as follows:

When a locomotive arrives in the roundhouse due for a washout, its blow-off cock is attached to a drop pipe from the blow-off main and the water in the locomotive boiler is blown through the blow-off main by the pressure of the steam behind it in the boiler, to the washout system. At the system the blown off water is passed through a coke filter which removes the sludge and suspended matter. The filtered water then passes to a storage reservoir and is forced back to the roundhouse by means of a pressure pump, which is part of the system.

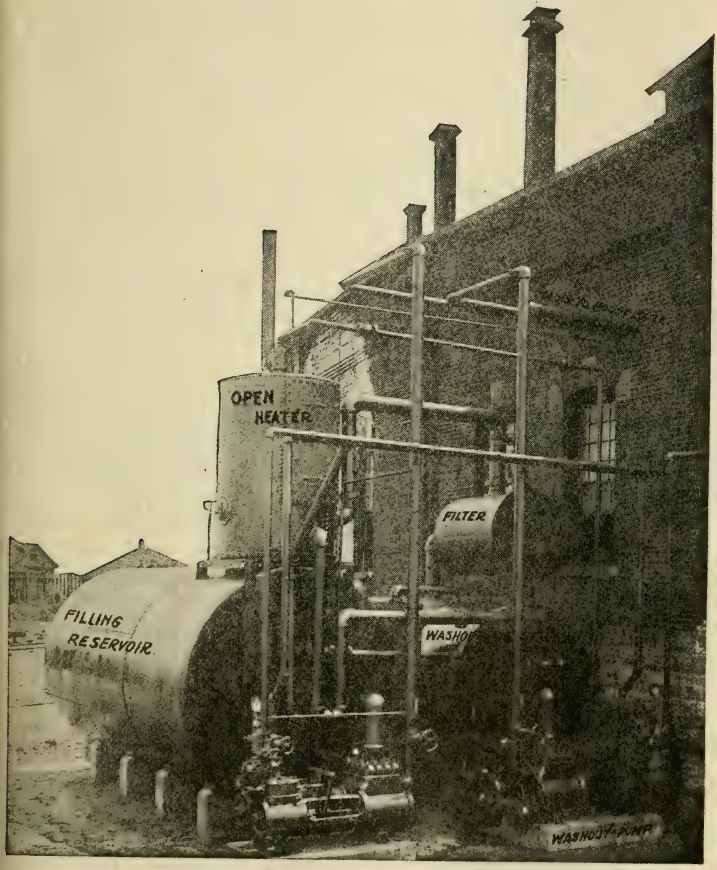
The washout main in the roundhouse has its series of drop pipes to which the washout hose is attached so that the locomotive can be washed conveniently.

After the water has left the locomotive the steam which the boiler contains passes through the same blow-off main to the washout system and is condensed automatically by cold water in a specially designed open heater, as shown in the illustration. From this heater the hot water obtained passes to the filling storage reservoir and is conducted from it back to the filling main in the roundhouse by means of a second pressure pump, which is also part of the washout system. Convenient drop pipes from this filling main are also installed in the roundhouse so that the locomotive may be filled through its blow-off cock by means of a hose.

Means are provided at the washout system for regulating the temperature of the blown off water so that it will not be too hot to handle for the men washing the locomotive. These means consist of an automatic thermostat which admits cold water to the suction pipe between the washout storage reservoir and the washout pump.

Other means are provided for maintaining a consistent amount of water in the two storage reservoirs so that the system is provided with water at all times.

The only source of heat for washing and filling purposes which the National system has is that received from the blow-


OPEN
HEATER
FILTER
FILLING
RESERVOIR.

ing off of locomotives and the exhaust from the two pressure pumps. It is claimed that:

Savings are effected in time as the locomotives do not have to wait to be cooled off after reaching the roundhouse.

Savings are effected in the use of water as the water blown off from each locomotive is sufficient to wash the same locomotive, thereby doing away with the cost of fresh water for this purpose.

Savings are effected in the use of coal as the locomotives can be fired up in less time after being filled with hot water than they could under the old method of filling with cold water. Coal is also saved in the blower line as this is not used for so long a period while the engine is blowing off.

Savings are effected in labor as the same number of men can wash out more engines with the National system per day than they could using the cold water method.

Savings are effected in locomotive hours as an engine can be blown off, washed, refilled, fired up and ready for service in from two to four hours less time than with the cold water method.

CLEANING LOCOMOTIVE ARCH TUBES

In order to secure more perfect combustion of the fuel in locomotive fire-boxes, a large number of prominent railroads have now adopted a brick baffle in the form of an arch over the fire bed. This baffle assists in mixing the products of combustion with the air that is admitted above the fire and also acts as reflector of the radiant heat of the fire into the escaping gases.

On account of the enormously high temperature over the fire, unprotected metal cannot be used for supporting the brick and tile of which the baffle is composed, therefore tubes containing water are employed. The tubes are curved in the form of an arch and communicate with the water jacket of the fire-box, a continuous circulation of water through them being therefore insured; in fact the locomotive arch tubes become an important addition to the heating surface of the boiler.

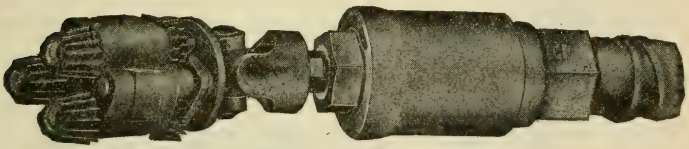
As these tubes are directly over the fire and at its hottest point, water is, of course, evaporated in them at an enormous

rate and if the water contains any scale forming material, scale is sure to collect in these tubes quicker than in any other part of the boiler. Furthermore, while a thin layer of scale might be tolerated on the flue tubes, the arch tubes have to be kept clean as possible. Because of the enormously high temperature here encountered, any material, such as a thin layer of scale, which retards transmission of heat, is liable to result in overheating of the tubes, causing them to bag, blister and burn out.

As stationary boiler practice has well indicated, the only effective method of removing scale from water tube boilers is by means of an efficient turbine cleaner. Therefore locomotive arch tubes should be periodically cleaned by means of a cleaner of this type. However, the ordinary type of cleaner is not satisfactory on account of the curvature of the tubes.

LAGONDA ARCH TUBE CLEANER.

The Lagonda is a special type of cleaner in which the body or turbine part of the cleaner is exceptionally short,

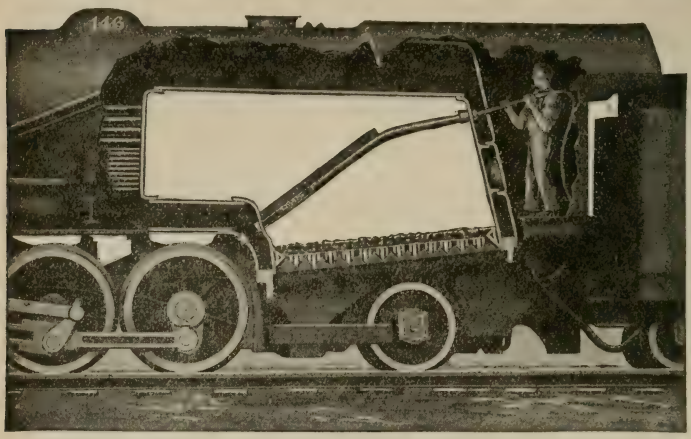


Lagonda Air or Steam Driven Cleaner for Locomotive Arch Tubes

and the cutting head connected to it by means of a toggle joint. The use of this cleaner in removing scale from the arch tubes is clearly illustrated.

The air or steam driver cleaner is shown equipped with the well-known Weinland quick repair head. This head is so constructed that it has no long spidery arms, which can become bent or jammed in the tubes. Cutter wheels are carried on freely swinging arms, which are forced out against the scale by the action of centrifugal force but a stop prevents them from swinging to a diameter greater than that of the

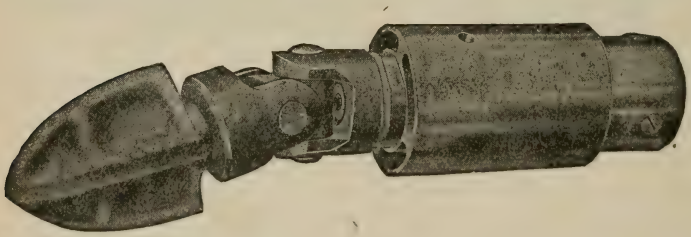
tubes, thus injury to the metal is impossible. This feature, together with the fact that in the quick repair head, dull



Arch Tube Shown in Illustration Being Cleaned by a Lagonda Arch Tube Cleaner

cutter wheels can be replaced by new sharp ones, makes it a most efficient cutter for removing scale from tubes.

The water driver cleaner shown has a toggle and drill

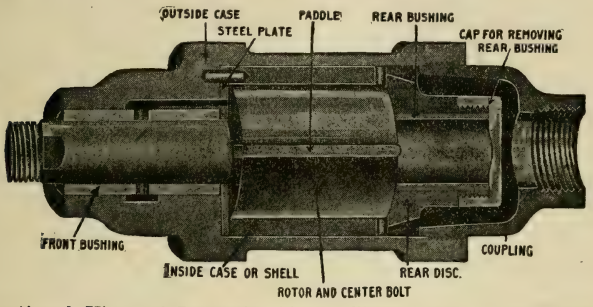


Lagonda Water Driven Arch Tube Cleaner Showing Toggle Joint and Drill Head

head attached which is preferred by many to the cutter head.

With either cleaner head the body of the turbine is so designed that it cannot pass through the tube until the cutter

head has removed all of the scale; thus when once the cleaner has passed through the arched tubes, it is certain that every



Sectional View of Lagonda Air or Steam Arch Tube Cleaner

vestige of scale has been thoroughly removed. At the same time the shortness of the body and the use of the toggle joint permit these cleaners to pass through curved tubes with the greatest freedom.

The cleaners are built in any size from 2 to 4 inches, and operate satisfactorily on from 40 to 60 pounds air or steam pressure and 100 pounds or more water pressure.

When the air or steam driven type of cleaner is used an automatic lubricator such as is shown in the accompanying illustration, is recommended. This insures thorough lubrication of the cleaner with less oil, reduces wear and tear and increases the efficiency as all oil passes through the small flexible tubing and does not allow any oil to come in contact with the rubber hose.

Lubricator

THE DEAN BOILER TUBE CLEANER

The Dean boiler tube cleaner is a pneumatic vibrator which removes scale from the inside or outside of tubes of boilers, condensers, or evaporators. It cleans from ten to thirty tubes an hour, and besides removing the scale from the water side of the tube, it removes the caked soot from the fire side.

It is operated by compressed air or steam and works on the principle of the ordinary steam engine.

The illustration above shows a sectional view of the Dean.

Power passes through the nozzle A to the chamber B. Then as valve .04 is thrown back and forth the power is admitted alternately through the ports C, C to each end of

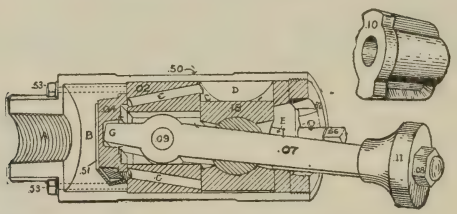


Fig. 1

SECTIONAL VIEW OF THE DEAN

Vibrator Heads ".11" and ".10" Are Interchangeable, Making the Cleaner Adaptable to Return Tubular or Water Tube Boilers

the piston chamber D, acting on the piston .18 and giving the vibrator .07 its vibratory motion.

The vibrator taps the tube at the rate of from 3,500 to 10,000 times per minute. The rapid movement of this vibrator sets up a series of vibrations in the boiler tube and it is the localized tremor thus created that removes the scale; the scale is loosened from the tube surfaces.

Where the scale is on the outside of the tube it falls in showers to the bottom of the boiler; where it is on the inside, it is broken into small pieces and driven out by the exhaust.

It is claimed that these vibrations are properly controlled and cause no damage, neither do they affect the solidity, strength, or durability of the tube, or the header to which it is attached.

Boiler tubes are cold-drawn steel shells, and when fastened into the headers at the tube-ends can be made to vibrate at a tremendous rate without a particle of injury, and yet they would be quickly damaged by a series of blows of comparatively low speed.

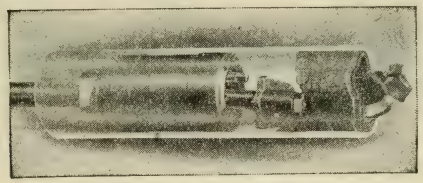


Fig. 2
The Dean Removing Scale from the Tube of a Water Tube Boiler

At the high speed-rate of operating the Dean boiler tube cleaner it is impossible for the vibrator to do injury because, even without the fine adjustment, there could be no great power to a blow.

This vibratory movement can be regulated to such a mechanical nicety that at the highest possible speed of the

Fig. 3
The Dean Operating in a Stirling Tube

Dean it will not strike the tube surface—a gentle tapping is the limit; therefore, in any case, a sound tube will never be injured when directions for operating are followed.

If the Dean were operating in the center of an 18-foot tube, the vibration at 8 inches inside the header would be so slight that it could hardly be detected even with the most sensitive instruments.

The Dean is claimed also to be effective for boiler inspecting and locating boiler weaknesses before they get far enough to cause trouble.

Scale has a natural affinity for cracks, crevices, and joints; there it collects in patches and layer upon layer, acting as a cement of the most deceptive kind. Particularly where the tube and header join, scale collects and causes the joint to loosen either through corrosion or by preventing expansion, and the regular use of the Dean will disclose a loose or weakened tube as soon as it starts to vibrate, and, also, the scale will be removed.

By simply changing the vibrator head it may be changed from a water-tube cleaner to a fire-tube cleaner. By being

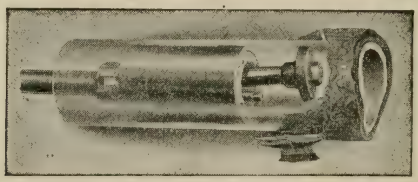


Fig. 4
The Dean Removing Scale from the Tube of a Return Tubular Boiler

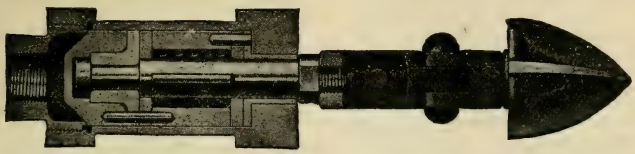
a soot cleaner as well as a scale remover, in an arch tube it removes soot and clinker from the outside and scale from the inside in the same operation.

CYCLONE ARCH TUBE CLEANERS

The Cyclone arch tube cleaner is a tool for cleaning locomotive arch tubes. It is powerful and efficient, and made in sizes to meet all requirements. It should be operated by air whenever possible, although very satisfactory results have been obtained with steam. Air is preferable, as the high temperature of steam is liable to expand and loosen the tube. When it is necessary to use steam, a small stream of cold water, supplied from a ¾-inch garden hose and flowing into the tube being cleaned, will prevent all damage from heat.

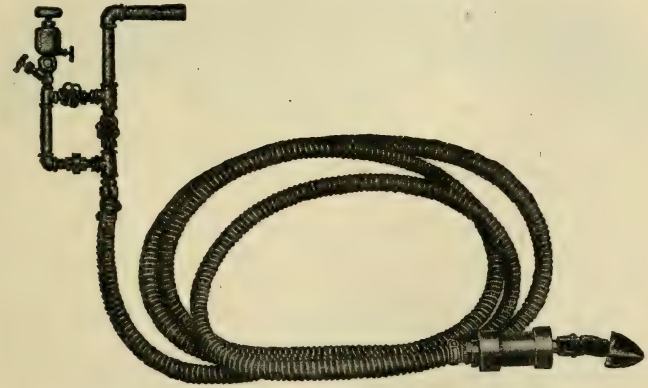
The motor of this machine is very compactly built. It

consists of an outer casing, in which is enclosed a removable hardened steel cylinder, in which revolves an eccentrically mounted shaft with a longitudinal slot, in which a pair of semi-balanced blades reciprocate. These blades are placed



Cyclone, Sectional View, with Extra Heavy Universal Joint and Drill for Heavy Scale

side by side in the slot and are balanced, so as to reduce the friction between the edge of the blades and the cylinder to a practically negligible quantity. Provision is made for taking up the wear in the blades automatically, which insures a



Illustrating Method of Connecting Up "Cyclone" Cleaner and Lubricator

perfectly tight joint between the edges of the blades and the cylinder wall.

Air or steam is admitted to the cylinder through longitudinal ports in the walls thereof, which in turn communicates

with the cylinder at different points throughout its length, producing uniform pressure on the blades. As the blades are mounted in the slot in the shaft, this pressure on the blades causes the shaft to revolve and thereby drive the cutting head. Air is conveyed to the machine by an oil-proof hose.

Lubrication is provided by placing a sight feed lubricator, which is attached to the air supply line as shown in the accompanying cut, and oil is conveyed by the air, through the hose, into the cylinder of the machine, and is then distributed to the bearings. The front bearing opens to the atmosphere, and the rear bearing is surrounded by a recess that is vented to the atmosphere. From this it will be readily understood that the air after entering the cylinder, is forced by pressure into the front and rear bearings.

Illustrating a Cleaner in a Bent Boiler Tube

This cleaner is operated by from 60 to 75 lbs. air pressure, and consumes from 45 to 50 cubic feet of free air per minute. Where air is used, the sight feed lubricator should be adjusted to drop from fifteen to twenty drops of oil per minute, and before starting up the machine a small quantity should be poured into the hose to furnish oil to the bearings until the lubricator has time to furnish a sufficient supply.

When the machine is operated by steam, the pressure should never be allowed to exceed 50 lbs. In operating the machine with either air or steam, the power should not be turned on until after the cutters have been inserted into the end of the tube.

The Cyclone Water Turbine, also illustrated, is specially designed for passing the bends in locomotive arch tubes, and

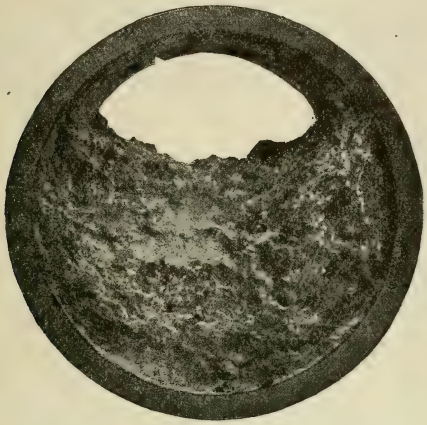
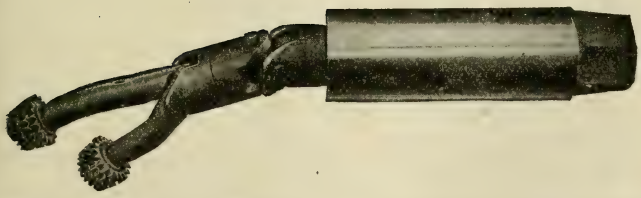
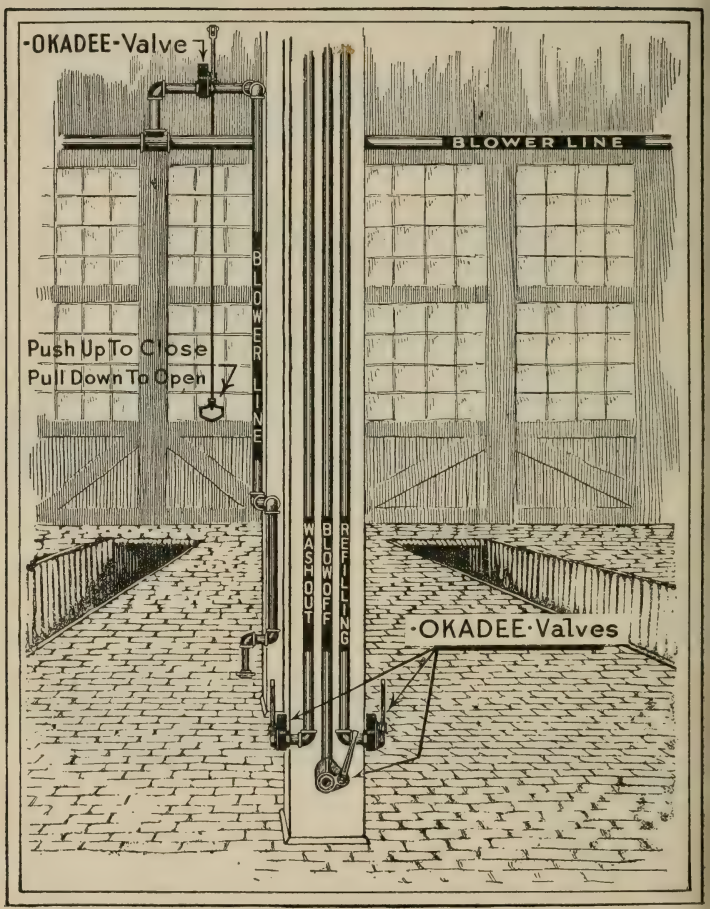


Illustration of a Badly Scaled Tube



Water Turbine—Motor, Two-Arm Head and Universal Joint, Used for Arch Tubes of Small Size

it is claimed to be the first cleaner ever used for this work that proved to be successful. The machine can be operated successfully by from 80 to 125 lbs. of water pressure.



Section of Engine House Showing Straight-Port Valve Used for the Blower Line and Also Washout, Blow-off and Refilling Line of a Hot Water Washout System
(See "Blow-off Valves" for Description)

WATER GAUGES AND GAUGE COCKS.

In order to determine the height of the water in the boiler, a glass water gauge is attached to the boiler (see plate "American Type Locomotive," part No. 251) by which the engineer can see at a glance the water level. The plain water gauge is so familiar to the ordinary practical man that it will be sufficient here to illustrate and describe a few of the improved forms which automatically shut off the flow of steam should the water glass break while in service.

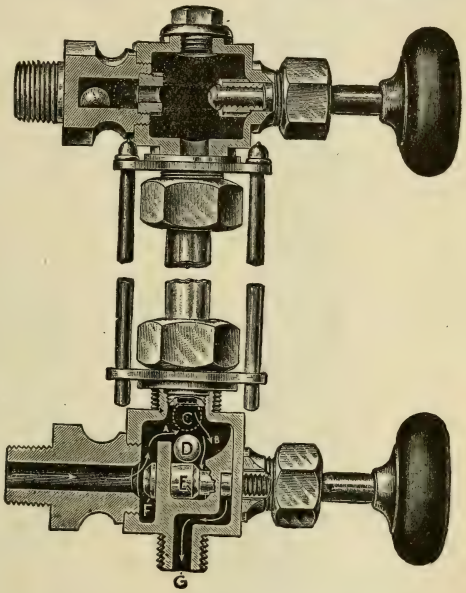


FIG. 1.
Pemberthy Automatic Water Gauge.

Fig. 1 shows a combined drip-cock and automatic water gauge. The automatic device or ball (*D*) is moved and agitated every time the handle is turned and gauge glass blown out through the

valve (*E*) to waste pipe at *G*, and cannot, therefore, become stuck fast by lime or other sediment. It will readily be seen that it is impossible for the two little balls to go to their seats except when the glass breaks and they take the positions shown by dotted lines.

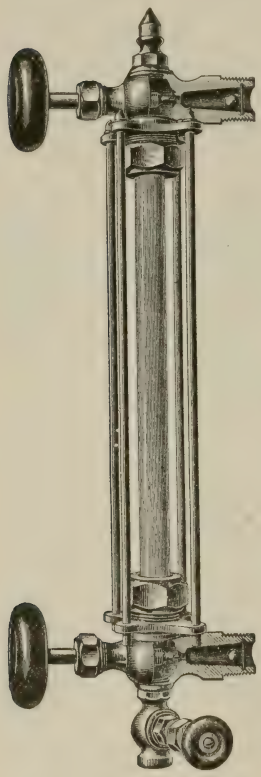


Fig. 2.
Star Self-Closing Water Gauge.

To blow off, the lower handle is turned a half turn to the right, or toward the closed position for valve (*F*).

E is a double-seated valve shown by Fig. 1 as off from both seats, its position when the gauge is being blown off, which is accomplished by simply turning the lower handle, no pet cock being used. The steam follows the course shown by the arrows (*B*) to the outlet (*G*), the steam pressure being *down on the ball.* In closing, the partition at the left of the ball (*D*) prevents the action of the boiler pressure from suddenly moving the ball to its seat. If, however, the glass break, the rush of steam to the glass, via arrows (*A*), causes an eddy or vacuum which immediately throws the ball to its seat, shown by ball *C* (dotted lines).

Fig. 2 shows a slightly different form of automatic water gauge. Should the glass accidentally be broken, the steam and water rushing out will force the balls up, and close the passages.

After a new glass has been put in place, slowly screw in the wood wheels; the needle projections on the stems will force the ball away from the openings, and leave the passages free and unobstructed again.

Klinger Reflex Water Gauge.—With the common form of glass-tube water gauge, many times it is impossible to ascertain the amount of water

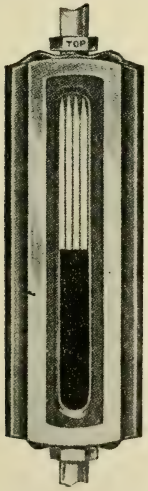


Fig. 3.
Type
H 5

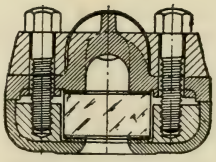


Fig. 3.
Type
N 5

in the boiler, rendering serious mistakes possible. In the Klinger Reflex gauge these conditions are

claimed to be entirely eliminated, as the amount of water in this gauge always appears black, which effect is produced by the peculiar shape of the observation glass.

The gauge consists of a metallic casing, capable of standing high pressure, which may be attached to any existing boiler mounting. Into this casing is inserted an observation glass, ½ to ⅝ inches in thickness, of specially hardened glass, which is claimed not to "fly" even under the most sudden changes of temperature, and which will resist a very high pressure.

This observation glass is so shaped that it will reflect the light in that part of the gauge which contains the steam, whereby this part of the glass becomes opaque and of a bright lustre, while in the remaining part, containing the water, the light is not reflected, but passes in a slight deflection to the rear of the gauge. The glass being transparent in this part of the gauge, the water will appear of the dark color of the background of the casing.

Maintenance of Gauge.—When putting up the gauge for the first time, or after it has been off for repairs, "follow up" the bolts uniformly as soon as the gauge is hot, to take up any slack, caused by expansion. This "following up" of the bolts must be repeated occasionally, as expansion and contraction is liable to loosen the joints and cause leaks, which must be prevented in order to preserve the glass in good condition. Tighten all bolts uniformly at the same time.

When a leak is noticed take off the glass immediately, clean the glass and joint faces of the frame thoroughly and renew the gaskets if worn or ragged. If the gauge cannot be attended to immediately after a leak is noticed, shut it off, and do not use it until it has been properly repaired.

The gauge should be frequently blown out, in order to get rid of mud or other matter, which may injuriously affect the packing, and the glass itself.

Type N5, shown by a sectional view in Fig. 3, which is an improvement over the H5, is constructed in such a manner that the bolts, which hold the body together and the glass in place, draws the glass tighter to the frame when screwed up, thereby preserving the glass longer and reducing leakages.

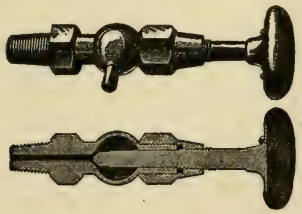
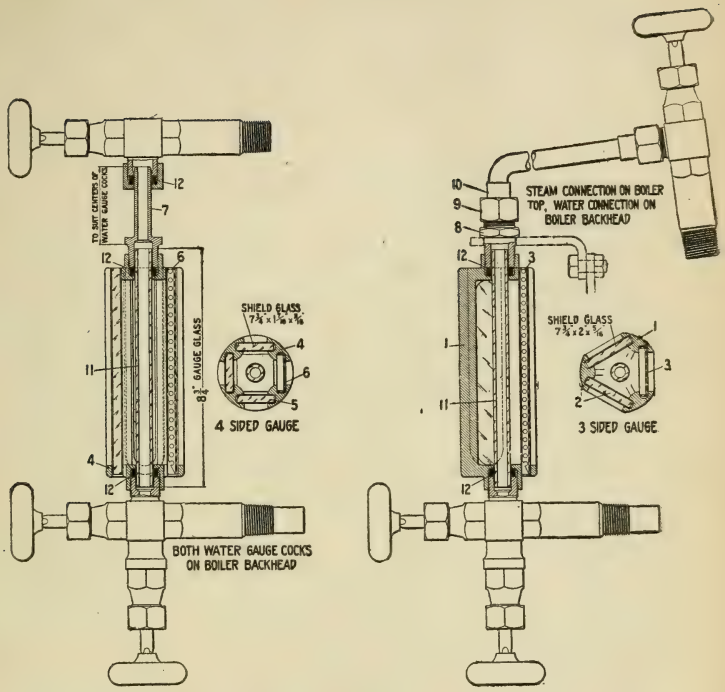


FIG. 4.
Regrinding Locomotive Gauge Cock.

Gauge Cocks.—In addition to the general use of glass water gauges, gauge cocks are used supplementarily for the same purpose. There are generally three, sometimes four. The top and bottom ones are placed on the boiler at about a level with the top and bottom of the glass gauge and are used to determine the water level when the glass gauge

is out of use from breakage or otherwise. Fig. 4 shows a standard pattern of locomotive gauge cock, so constructed that it can be separated for the purpose of re-packing or re-grinding the working parts without detaching it from the boiler while the necessary repairs are being made.



DELCO SAFETY WATER GAUGE AND SHIELD

1. Shield.
2. Shield Glass. } 3 Sided
3. Pressure Release Plate. } Gauge
4. Shield.
5. Shield Glass. } 4 Sided
6. Pressure Release Plate. } Gauge.
7. Nipple for Location on Backhead.
8. Nipple.
9. Coupling Nut. } For Location
10. Pipe Sleeve. } on Boiler Top.
11. Gauge Glass.
12. Gauge Glass Gasket.

DELCO SAFETY WATER GAUGE

Being a unit device, the shield goes on with the gauge—neither can be omitted, safeguarding against such neglect.

This is a one-piece, symmetrically shaped body, with top and bottom packing recesses always true and in line, in combination with a tubular glass water-level indicator, easily inserted in position in packing gaskets in top and bottom recesses, completely surrounded by the supporting shield body and inserted protecting glass slides on the face sides, release plate on the back, and tubular extension pieces to provide for vertical expansion movement. In this construction, neither gauge nor tubular glass can distort by expansion—all unsymmetrical shapes will distort.

It combines great strength and durability with lightness of construction, and uses exact length, commercial sized standard tubular glasses, with both ends fused, eliminating progressive fractures, internal, sidewise or twisting strains, water erosion or mechanical shocks.

The glass is free to expand, contract and assume natural positions, free from metal contact.

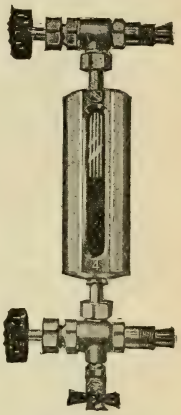
New tubular glasses are easily applied or renewed in service from three to five minutes time without removal from the cab.

ASHCROFT PRISMATIC WATER GAUGE

The Ashcroft Prismatic Water Gauge is fitted with a flat glass which, owing to its peculiar design, quality and temper, will not blow out under the highest pressures and temperatures or under sudden changes of either. The frequent breakage of glass tubes in stationary or marine boiler rooms or in the locomotive cab often results in injury to men. With the Ashcroft prismatic water gauge the danger from flying glass incidental to a gauge glass explosion is eliminated.

The water level is distinctly indicated at all times. The glass and its casing are so designed that the water shows black while the steam space takes on a silver appearance. This makes it impossible to mistake the water level, as it is claimed may often be done with the ordinary water glass, particularly if the boiler tends to foam.

The frame in which the glass is mounted consists of a front and a back portion, machined to true surfaces, making a perfect joint with the back gasket and front pad and insuring that most important condition — tight joints.

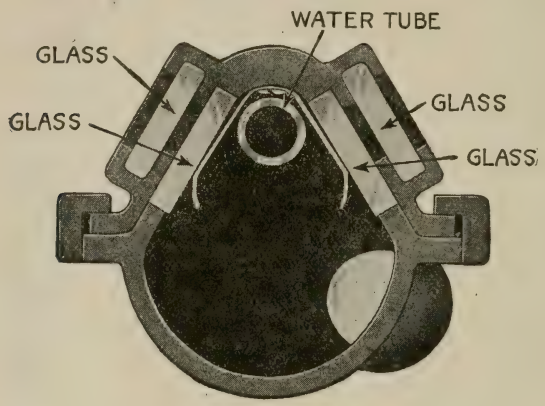


Ashcroft Prismatic Water Gauge

BABCOCK SAFETY WATER GAUGE

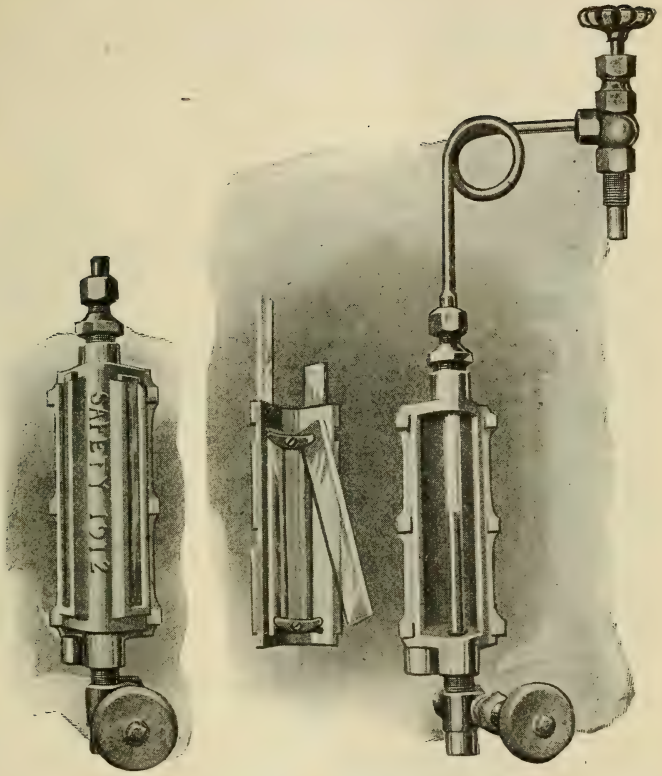
The Babcock water gauge is so constructed as to have no opening whatever into the cab. When the tubular glass breaks, every particle of glass is ejected through a pipe that leads below the deck. The reason why the glass cannot escape into the cab is because there are two "windows" of plate glass at each opening instead of only one and the inner glass is fixed at such an angle from the tubular glass that only a glancing blow can be struck on it by the particles of the exploding tube.

This breaks the force and the liability of cracking the inner plate; but even if it should be broken it absorbs the force of the blow and the outer plate still stands to prevent the particles of glass from being blown into the cab.



Sectional View

It is unnecessary to carry a stock of special protecting glass with this protector. The glass can be cut from ordinary plate glass.

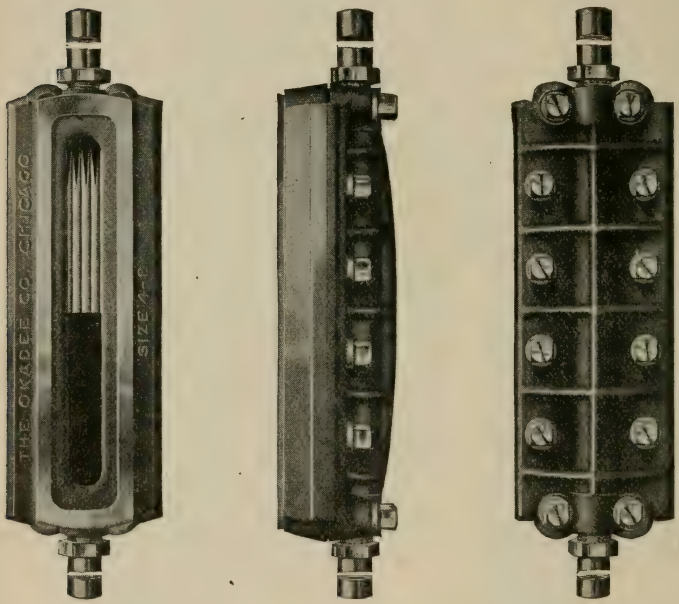


The Babcock Safety Water Gauge

OKADEE REFLEX WATER GAUGE

The water glass here shown has been used to great extent, in varying forms, on locomotives.

The water appears black and the steam space white, which is claimed as a distinct advantage over the ordinary tubular



Okadee Reflex Water Gauge

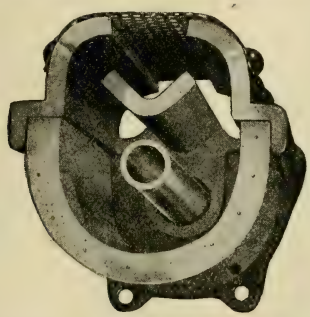
water glass; however its chief claims for merit are that it is safer at high pressures, rarely breaks, and when it does break the pieces of glass will not fly nor leak steam seriously.

The cage is made of drop forged steel of proper design to eliminate the warping of the parts.

THE IRONCLAD WATER GAUGE AND SHIELD

The Ironclad water gauge with the water glass protector has been in service on a number of railways for several years. It is practically a combination of this curved wired glass protection with an aluminum gauge body utilizing the ordinary tubular water glass which shows the water level in its true and natural condition.

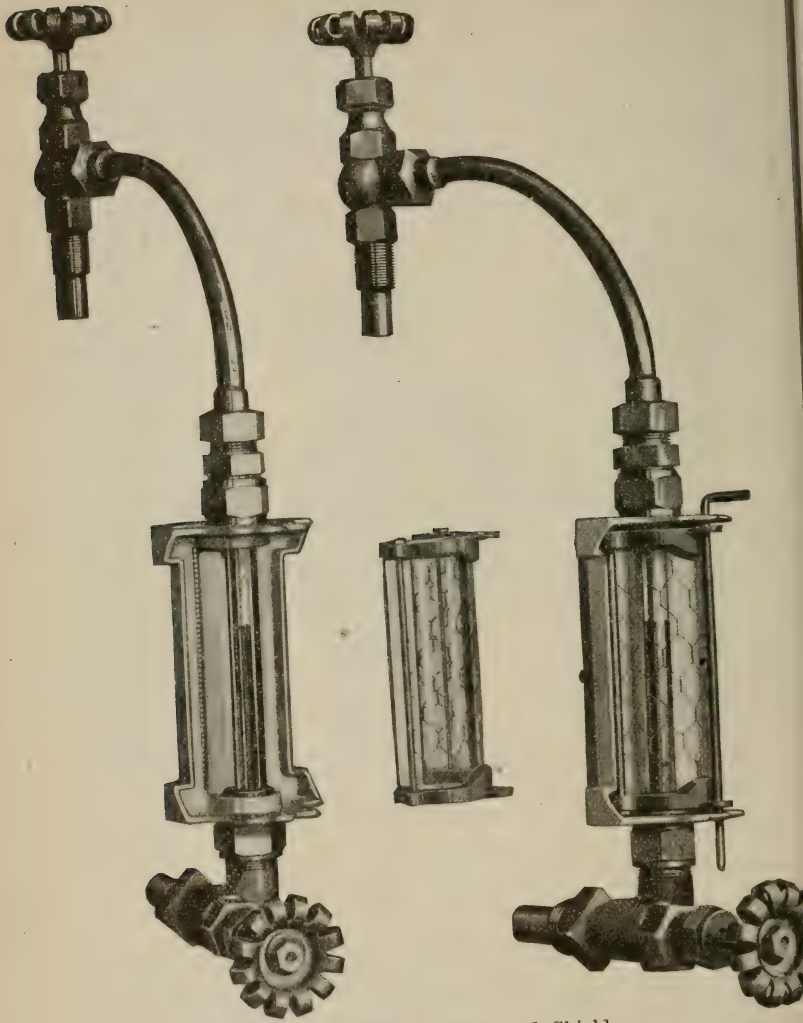
As shown in the illustrations, the curved plate wired glass fits into an aluminum gauge back which provides the necessary rigidity and alignment of the stuffing boxes, thereby preventing much of the tubular glass breakage. The use of a flexible copper pipe to the top water glass cock, located in a convenient point on top of the boiler is strongly recommended.



Cross-Section Ironclad Water Glass Shield

The finely tempered curved plate glass with its interwoven wire mesh successfully withstands all shocks and stresses from bursting of tubular glasses under maximum steam pressure, the most destructive of which are the expansive force of steam suddenly released from the tube, the impact of glass fragments at high velocity and the sudden rise of temperature, due to the escape of steam and water from the boiler.

A transverse section of the Ironclad water gauge on this page shows how the steam, water and fragments of glass must escape through indirect passages around the vertical baffle plate into the ample back space which allows the

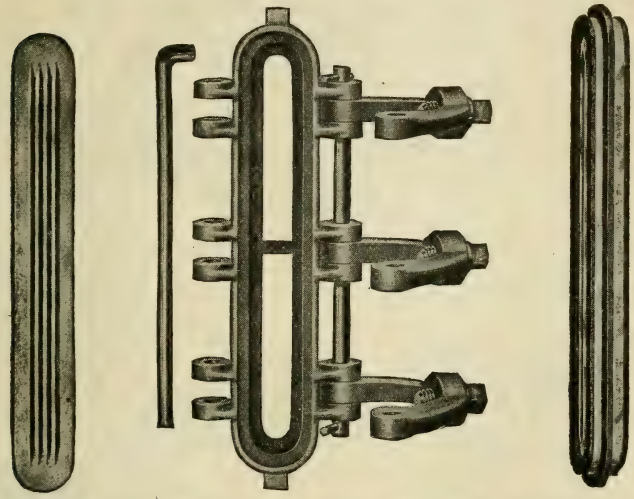


Ironclad Water Gauge and Shield

escape of steam pressure through the fine mesh screen, while the discharge port at the bottom releases the flow of water carrying safely some of the broken glass to the deck.

WILTBONCO REFLEX WATER GAUGE

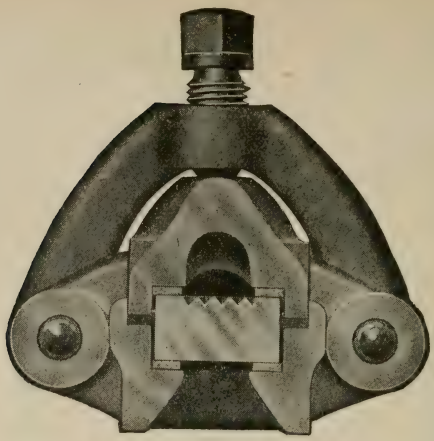
This is a development of the Klinger type of reflex water



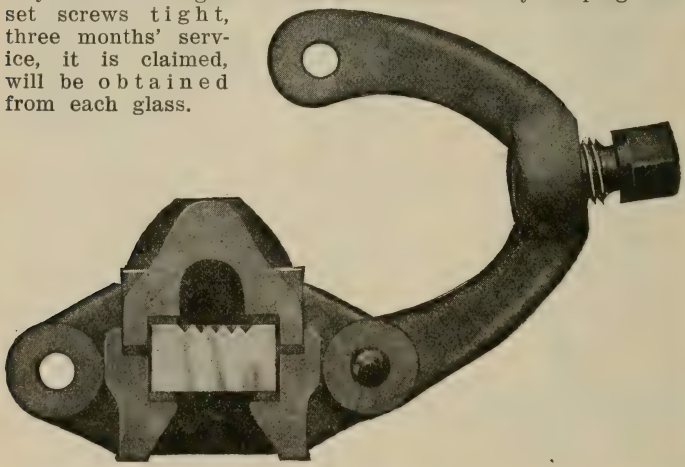
This Illustration Shows Front Piece and Yokes Without Glass, and Views of Glass With and Without Gaskets

gauge, used on the boilers of locomotives, warships, steamships and industrial plants throughout the United States.

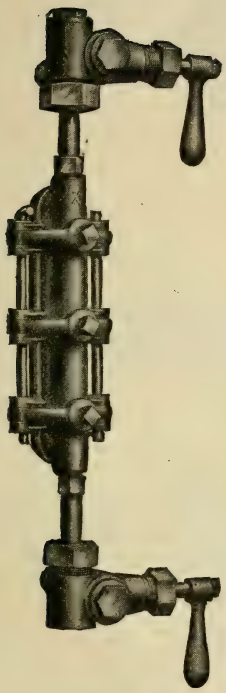
The above illustration shows the front piece and yokes without glass, of style "X" gauge; also views of the glass with and without gaskets.



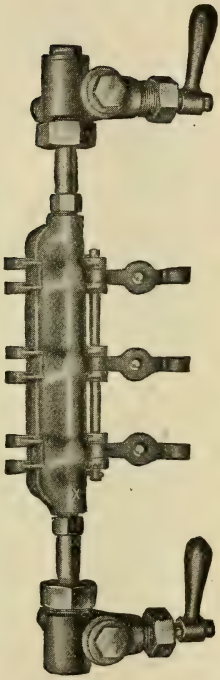
This cut shows a cross-sectional view of style "X" gauge, illustrating the method used in packing the glass in the frame. Besides the flat gasket on each side, as is usual with Klinger gauges, note the special gasket which passes all the way around the glass about at its center. By keeping the set screws tight, three months' service, it is claimed, will be obtained from each glass.



This illustration shows the yokes turned back in process of taking the gauge apart.

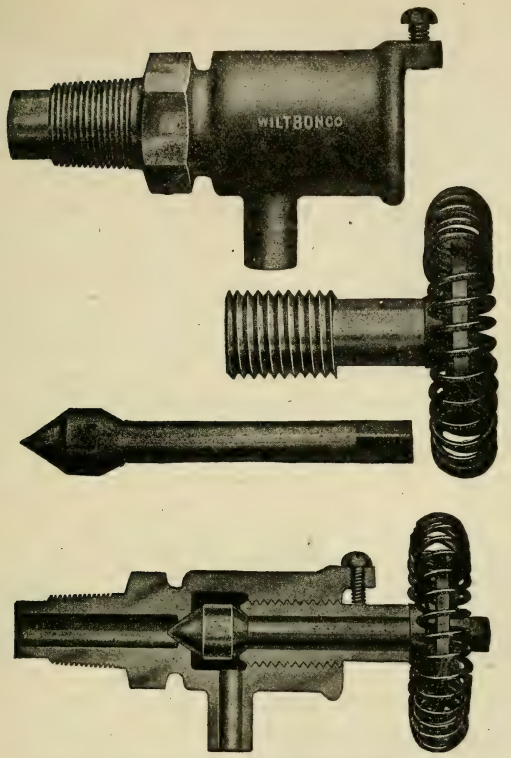


Back view of style "X" gauge in service, gauge fittings open. Notice the simple construction, with only three set screws used.



Back view of style "X" gauge out of service, with yokes turned back, gauge fittings closed. This illustrates clearly the ease in taking the gauge apart; the front piece may now be removed.

This cut shows the back piece of style "X" gauge, still attached to the gauge fittings, front piece and glass having been removed, gauge fittings closed. This shows the readiness in which this gauge may be taken apart without disturbing the boiler fittings.



WILTBONCO STEAM GAUGE COCK

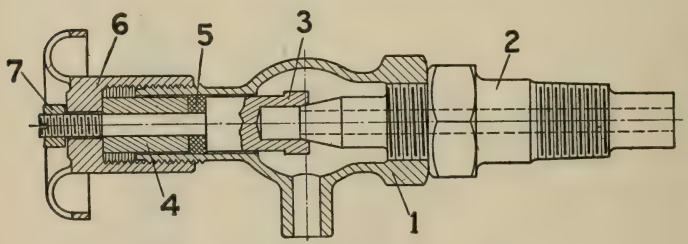
The above cuts illustrate the Wiltbonco steam gauge cock which is so designed that the seats on the stem and on the body may be ground in while there is pressure on the boiler by slightly releasing the handle and then turning the square end of the valve stem. In this manner the seats are very efficiently and quickly cleaned, thus insuring against a dripping gauge cock. The small screw serves as a stop, preventing the handle shaft from being unscrewed all the way out.

NATHAN NEVER LEAK GAUGE COCK

The following are the advantages claimed:—

First—Length of time during which it keeps tight without necessity of regrinding is due to the fact, when the gauge cock is opened it pulls valve 3 off its seat without turning it. This prevents cutting the seat or valve.

Second—This gauge cock will not jam. The valve has a long conical seat and is part of shank 2, which screws into the boiler. Movement of spindle and valve 3 is effected by threaded sleeve 6, which moves on the externally threaded neck of the body. There is a slack movement between the handle (which is cast on sleeve 6) and nut 7 on end of the spindle, which is part of valve 3, so that in opening, sleeve 6 moves slightly without turning spindle, and when it strikes nut 7, it pulls valve 3 off its seat and admits opening the valve with remarkable ease without ever sticking.



NEVER LEAK GAUGE COCK

Names and Numbers of Parts.

1. Body.
2. Shank.
3. Spindle.
4. Gland.
5. Packing Ring.
6. Packing Sleeve.
7. Top Nut.

Third—Ability to regrind with steam on boiler and thereby avoid killing engine is one of vital importance, not saying anything of loss of engine, expense, etc. To accomplish this result, turn back nut 7 above one turn, open handle 6 just

enough to loosen the valve from seat, after which a screw driver can be inserted in the slot in the end of spindle, and valve may be ground on its seat and made tight. There is always grit enough in water to accomplish this grinding. When reground, screw up nut 7, leaving slack between the handle 6 and the nut 7. The gauge cock has a long conical seat, which may be reground and recut many times before replacement is necessary.

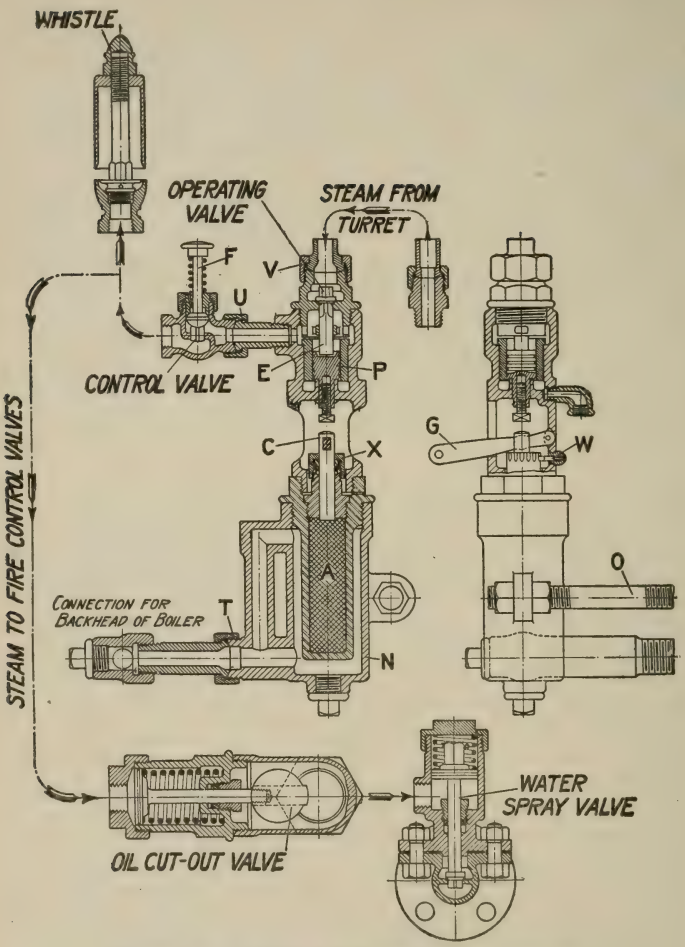
Fourth—When washing out the locomotive boiler, it is also required by law that gauge cocks be cleaned. This can be done without taking them out of the boiler. Open the gauge cock handle about one turn, and with a wrench unscrew body 1 from shank 2, which remains in the boiler. Clean the opening in the shank to boiler; when completed, replace body on shank; tighten with wrench.

No packing of gauge cock is required. Only one leather washer, 4, is used and but one gland, 5.

NATHAN AUTOMATIC LOW WATER ALARM AND FIRE CONTROLLER

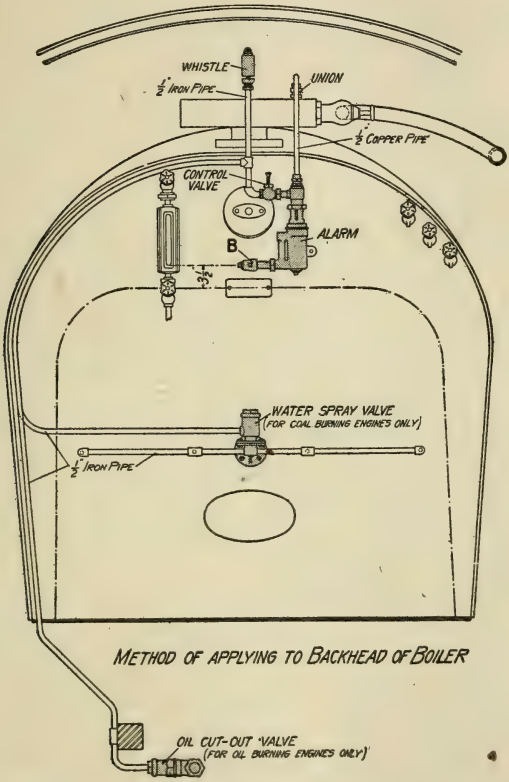
Construction and Mode of Operation.—The alarm is operated by the expansion of mercury within the steel cylinder. (A) surrounded by a suitable jacketed space. Normally and as long as the water in the boiler is above the prescribed limit, namely, 3½ inches over the highest point of the crown sheet, the jacketed space is filled with water from the boiler. When the water level falls below this limit, the water from the jacketed space drains back into the boiler and the space fills with steam, which, being of a higher temperature than the water, causes the mercury within its case to expand and force up the piston (C) which in turn comes in contact with the timing screw (D) at the lower end of floating piston (P) forcing the operating valve (E) from its seat, thus permitting steam to pass through it to the control valve and whistle as well as to the oil cutout valve, or to the water spray valve, according to the type of installation.

When the alarm sounds and the crew takes proper notice of it and puts the injector to work, the control valve is closed



Nathan Low Water Alarm and Fire Controller

manually by pushing down the valve stem (F) so as to stop the unnecessary blowing of the whistle and simultaneously to release the fire extinguishing valves. The control valve



Nathan Low Water Alarm and Fire Controller

is kept closed by steam pressure as long as the operating valve is open, and in the meanwhile, a small spray of steam blows through the control valve gland indicating to the at-

tendants that the valve is closed. On again raising the water in the boiler to the proper height, the jacket space again fills with water, causing the mercury to cool and contract, and allowing the steam pressure from the boiler to force down the floating piston (P) together with the mercury piston (C) which permits the valve (E) to close and the control valve (F) to open automatically. Approximately 15 minutes, however, elapse after the water is raised above the prescribed limit before the mercury contracts sufficiently to allow the valve (E) to close as described. The alarm is then ready to operate again should the water fall below this limit.

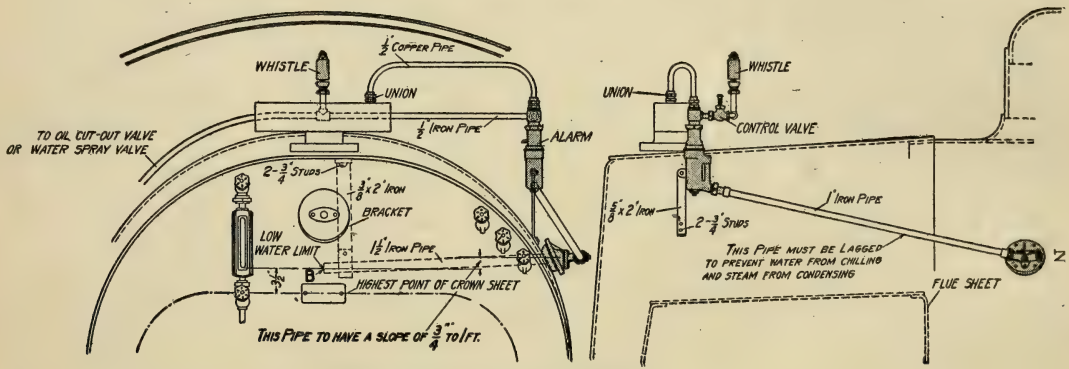
The Oil Cut-out Valve which is used only on oil burning locomotives to automatically cut off the fuel supply, closes within a few seconds after the steam passes through the operating valve. It is automatic by virtue of the steam acting on the piston (H) causing the valve disc (K) to close the ports and thus interrupt the flow of oil to the burners.

When the control valve is pushed closed to stop the blowing of the whistle, the steam in the pipe leading to the oil cut-out valve exhausts through the whistle, releasing the pressure on piston (H), when the oil cut-out valve opens automatically, allowing again the flow of oil and the re-lighting of the oil from the hot fire-box. Should the oil not re-light, the firing valve should be closed and the fire lighted in the usual way.

The Water Spray Valve which is used only on coal or wood burning locomotives operates in a manner similar to the oil cut-out valve with the difference that steam pressure against piston (L) opens valve (M) permitting hot water from the boiler to enter a series of spray pipes located just above the fire line. These water spray pipes materially reduce the heat between the fire and crown sheet. The water spray valve closes automatically as soon as the control valve is pushed down into the closed position.

The location of the alarm on locomotive boilers is governed by space considerations. There are two recommended locations in order of preference as follows:—

1. On the back head of the boiler.
2. On the side of the boiler.



Nathan Low Water Alarm and Fire Controller

When located on the back head, the center line of the low water connection to cylinder (N) is laid out 3½ inches above the highest point of the crown sheet. The alarm then operates when the water falls below this limit. The cylinder (N) is fastened to the boiler by the stud (O) in combination with the connection (B) cut for 1¼ inch — 12 threads tapered while the steam supply to the operating valve (E) is taken from the turret or other suitable place by means of a ½-inch copper pipe.

When located on the side, the flange connection (Z) is placed ahead of the fire-box flue sheet clear of all stays or crown bars. This application requires a special flange carrying a ball joint fitted to a 3⅞-inch dia. 45°-seat in the boiler, and held in position by 6 ¾-inch studs. The ball connection carries a 1 ½-inch iron pipe extending to the center of the boiler with a drop of 1 inch, and having its inner end located to cause the operation of the alarm when the water falls below the above mentioned limit, and supported by an ordinary wrought iron bracket made to suit. From the flange connection (Z) a 1-inch iron pipe runs to the alarm body placed conveniently within the cab, the pipe having a gradual rise of not less than 6 inches, being free from short bends and well-lagged. The cylinder (N) is identical in design to that used in the backhead application, the steam supply to the operating valve being taken from the turret by a ½-inch copper pipe.

The whistle must be located where the sound issuing from it will reach all parts of the cab. This is preferably within the cab.

The oil cut-out valve is placed on the engine end of the oil pipe to the burners. It is connected to the whistle pipe by a ½-inch iron pipe of suitable length and shape, and a T fitting. Rigidity is obtained by clamping to the engine frame or other suitable support as any individual case may call for.

The location of the water spray valve is governed by space considerations. The preferred location is on the backhead just above the fire line. The water inlet end fastens by means of flange and ball joint directly onto the boiler, while the water outlet is connected to a ½-inch iron pipe running

horizontally across the boiler backhead as illustrated, or along either side of the fire-box. From 2 to 4 ¼-inch pipe branches are placed at intervals along this pipe, depending on the width or length of the fire-box. These ¼-inch pipe branches extend about three quarters through hollow stay bolts which are drilled $\frac{9}{16}$ inch. The connection to the whistle pipe is by means of a ½-inch iron pipe and the T fitting.

THE MASON AIR BRAKE PUMP REGULATOR OR GOVERNOR.

This regulator is designed to automatically control the air pressure in the brake system for operating the brakes on railroad cars. It is placed in the steam supply pipe leading to the air pump, and regulates the amount of steam passing to pump, and allowing the pump to run just sufficiently to maintain the desired air pressure in the train service pipe.

Description.—The principle on which the Mason Air Brake Regulator works is that of an auxiliary valve (8), controlled by the air pressure from the train service pipe, through the medium of a metal diaphragm (24), and admits steam from the initial side of regulators through a port to operate a piston (19), which in turn opens the main valve (21), and admits steam to the pump. By referring to the sectional view, it will be seen that the steam enters the regulator

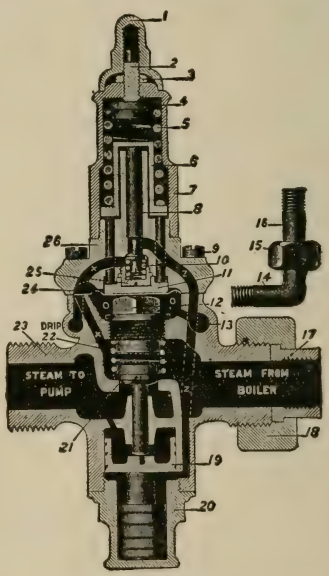


FIG. 1.
Mason Air Brake Pump Regulator.

at the side marked "steam from boiler," a small portion of it passing up through the passage (*XX*) to the auxiliary valve (8). This valve (8) is forced open by the compression of the large spiral spring (5) acting on the cricket through the diaphragm. This cricket (6) has three studs projecting down from the rim, which pass through three loosely fitting holes in the bonnet, the lower ends resting on a button (11) which sits on the diaphragm, so that in opening the valve (8) the diaphragm is also forced down. As soon as the valve (8) is opened, steam passes through and into port (*Z*), down under piston (19). By raising this piston (19) the main valve (21) is opened against the initial pressure, since the area of valve (21) is only one-half of that of piston (19). Steam is thus admitted to the pump. A connection with the main air pipe is made as indicated; and, by a passage, air enters the chamber below the diaphragm, which carries the cricket (8), as before stated. When the pressure in the air pipe (16) and chamber (*O*) has risen to the required point, which is determined by the tension of the spring (5), the diaphragm is forced upward by the air pressure in the chamber, carrying with it the cricket (6), and allowing valve (8) to close, shutting off the steam from piston (19). The main valve (21) is now forced to its seat by the initial pressure, shutting off steam from the pump and pushing the piston (19) down to the bottom of its stroke. The steam beneath this piston exhausts freely around it—the piston being fitted loosely for this purpose—and passes off into the pump. The leakage past the auxiliary valve (8) passes up under the cricket and out into the spring case, where it

makes its escape down through the cricket holes to the upper side of the diaphragm and into the drip. It will be seen from this that, when the pressure in the brake pipe has reached a predetermined point, the pump will be automatically stopped; and, when the pressure in the brake pipe is reduced by applying the brakes, the pump will quickly produce a surplus pressure in the main reservoir to insure the speedy release of the brakes and recharge the auxiliary reservoirs. The piston (19) is fitted with a dashpot, which prevents chattering or pounding when the air pressure is suddenly reduced.

Directions for Attaching and Repairing the Regulator.—Place the regulator in the steam supply pipe to the pump and so that steam will flow through it in the direction indicated by the arrow cast on the body. With a small pipe make a connection from the train pipe to the air pressure connection (15 and 16) on regulator. The one-eighth inch tapped hole marked "Drip" must be left open, but it may drip from either side by reversing the plug.

Before connecting the regulator to pump, the steam pipe should be thoroughly blown out, in order to expel all dirt. If the piping is new, steam should be allowed to flow through slowly for some little time, in order to burn off all glummy oil and grease, which would otherwise be carried into the regulator and thus clog the working parts.

When ready to start, open both steam and air valve wide, then remove the cap (1) which screws over the screw (2), slack off the jam nut (3), and with the key gradually screw down the adjusting screw (2) until the desired air pressure is obtained. The regulator is

then properly set. Screw the jam nut (3) down firm and replace the cap (1).

If the regulator should fail to hold the desired pressure, it will probably be due to the fact that some dirt or chips from the pipe have lodged on the seat of the main valve (21), or possibly under the auxiliary valve (8). To open the regulator proceed as follows: Shut off both steam and air pressure from the regulator. Remove the cap (1), and with the key unscrew the adjusting screw (2), until all tension is removed from spring (5). Then take out the screws (9), and remove bonnet (7), diaphragm (14) and button (11). Take out the plug (12) and the spring (22). The threaded rod which accompanies each regulator can then be screwed into valve (21) which should work easily. Pull out this valve and examine both valve and seat, cleaning them thoroughly. Then insert the rod through the valve stem guide, screw it into the piston (10), and see if it works up and down easily. It will not be found possible to raise it suddenly, as the dash-pot piston (20) will restrain it. After pulling up, let go of the rod suddenly, and, if the piston drops easily, it is all right. In case it does not, unscrew the dash-pot cap (20), from bottom of the regulator, pull out the piston (19), and clean it with kerosene or spirits. If it seems somewhat tight, rub it with fine emery cloth, being very careful to thoroughly wipe it off before replacing. Before screwing on the bonnet, examine the auxiliary valve (8). To do this, remove the slot-headed plug (25) in bottom of bonnet, also the small spring (10). The valve (8) can then be taken out and examined. This valve should work perfectly free. In taking out the plug (25), there may be a burr,

caused by the screw driver, which should be dressed down before replacing, as this plug forms a guide to centralize the diaphragm button (1), which should fit over it freely. In replacing the bonnet (7) be sure that the zero marks on the side and those on the body correspond; also see that the diaphragm (24) is replaced so that the port holes in it correspond with the holes in the body. Carefully clean the diaphragm as well as the place where it makes its seat. Do not use washers or gaskets of rubber, or any other compound, in making connections. They will burn, and the pieces will get into the regulator. Two copper gaskets for making the steam connections are sent with each regulator.

NOTE.—The reader will find the several forms of Westinghouse Standard Air Pump Governors fully illustrated and described in the volume devoted to the Air Brake.

LOCOMOTIVE STEAM WHISTLES.

The locomotive steam whistle, aside from its more ordinary uses, is distinctly a safety appliance and a danger signal as well. The tone should be such as not to be disagreeable to the ear of passengers and others, and yet clearly audible to all whom it would

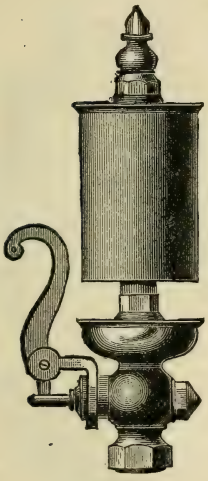


FIG. 1.
Bell Whistle.

FIG. 2.
Chime Whistle "Locomotive Style."

warn or to whom it would convey signals. Fig. 1 shows the ordinary bell whistle with steam valve and lever attached. As an improvement in tone, various types of chime whistles were made at different railroad

shops. They were, many times, a bunch of pipes of such different lengths as to cause a harmony of sound. The manufacturers have improved on this type, making a chime whistle out of a single bell, as shown in Figs. 2, 3, 4 and 5. This is done by dividing the bell into three or four sections whose depth varies. thus producing different but harmonious tones. Fig, 2 shows what is termed the "locomotive style" because of its upright valve. The slide valve type is clearly shown by Fig. 3, which illustrates this style of Crosby whistle, used on a large number of locomotives and said to be the original single bell chime whistle marketed.

This whistle is fully adapted to severe railway service. In the distribution of material and the uniting of the several parts great care has been exercised in the designing and making of it, so that it shall resist successfully the jars and concussions which may arise in use on a locomotive. In all whistles whenever the valve is badly worn the cup is of little or no value. To meet this condition the valve has been made so that the seats are the same as are employed in the Crosby spring-seat valve, shown elsewhere in this volume, and are seen in the above mentioned cut marked (*A*) and (*B*).

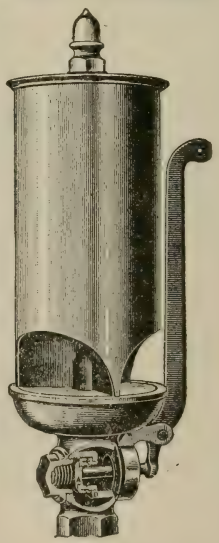


FIG. 3.
Crosby Chime Whistle, Slide Valve Type.

These seats can be renewed at a small expense whenever they are injured or worn, thus preserving the entire whistle for a very much

longer time than formerly when in constant service. This applies only to the sizes five-inch and six-inch diameters of bell, which are the ordinary ones for locomotives.

Fig. 4 represents the Crosby single bell chime whistle. It differs from the whistle last illustrated in having a compound automatic whistle valve incor-

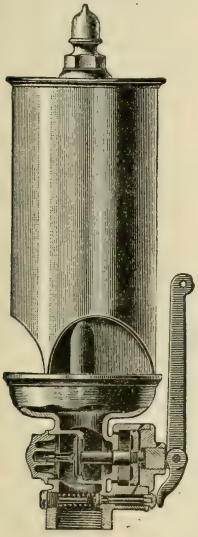


FIG. 4.
Crosby Single Bell Chime Whistle.

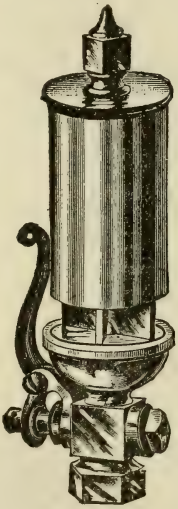


FIG. 5.
Ashcroft's Four-Tone Chime Whistle.

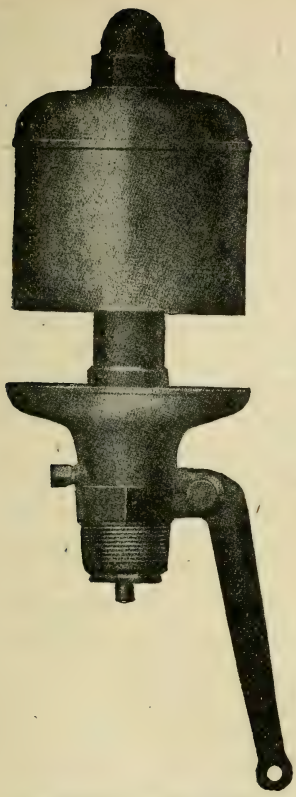
porated as a part of its construction, in the place of the ordinary whistle valve. It has been found by experience that whistles, when used under the high pressures which are to-day in almost general use, are sounded or operated with difficulty and great exertion. To meet this difficulty, that is, to sound whistles of any size, no matter what the pressure is,

with little effort, this whistle was designed. The ease of operation can be readily seen by an examination of the cut. The only valve which must be operated by force is the small one which is held closed by a spiral spring pressed to the foot of the lever. A slight pull on this lever pushes inward the valve and permits the steam to flow into a chamber and to open automatically the large valve and sound the whistle. By this device the largest whistles under the highest pressure of steam are operated with ease and rapidity.

The Ashcroft four-tone chime whistle is shown in Fig. 5. These whistles are pitched to first, third and fifth of the common musical scale, which harmonizes the sound and gives an agreeable musical chord.

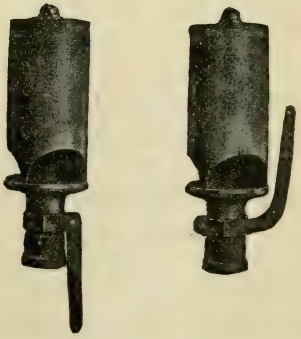
The chime whistle has proved much more penetrating than the single bell whistle, as shown in Fig. 1, and can be heard at a greater distance, without the harsh, disagreeable noise.

Many railroads have adopted a chime whistle for passenger runs, in order to distinguish passenger from freight trains; but new locomotives are being added so rapidly, and are of such size as to haul very long trains, and thus require a whistle of maximum penetrating qualities to be heard at the rear end of the train.



Hancock Plain Whistle

The Hancock Single Bell Whistle.—The accompanying illustration represents the Hancock plain whistle for freight engines. This whistle has a much higher pitch than the chime whistle and is very simple and substantial in its construction. The bell, bowl, plate and valve are made of composition. A bolt of cold rolled steel extends its entire length, holding the parts together. The stem supporting the bell and the nut are of cast iron. The lever is a steel casting. The slot in the valve, where it engages the end of the lever, is provided with a chilled iron piece which is cast into the valve. The end of the lever which operates the valve is also hardened. The screw, shown in cut, prevents the valve from dropping out when the lever is removed.



New Type of Hancock Chime Whistle

STAY BOLTS.

The corrugated fire box for locomotive use being only in the experimental stage, it may be said that practically every locomotive has several hundred stay-bolts which form the connecting and strengthening link between the fire-box and the outer shell of the boiler. (For the description and construction of the locomotive boiler, the reader is referred to Vol. I, "The Science of Railways," where he will find many engravings relating thereto; also to Plate I, "The American Steam Locomotive.")

The great expense to railroad companies caused by the frequent breaking of stay-bolts, requiring renewals of same and the consequent laying up of the engine out of service, have led motive power men to consider the means of remedying this evil. A number of different devices have been used in the effort to accomplish this end. Some of them have proven fairly satisfactory; others have failed and been abandoned. In soft water districts where the breakage of stay-bolts is not so frequent and is, therefore, not such a serious matter, some of these devices have apparently given good results; at least the mechanical construction of the device has received credit where it is more than likely the credit was due to soft water and careful handling of engine by the engine crew. But on roads not so favorably situated, where the water is heavily impregnated with lime, sulphur and other ingredients which deposit a hard scale on

the fire-box sheet, stay-bolts and flues, the conditions are very much more severe; the frequent leaking of the flues making it very difficult for the engine crews to handle their fire and water supply with the regularity desired and the incessant rising and falling of the temperature in the fire box causes a corresponding expansion and contraction of the fire-box sheets.

The sheets being covered with scale of greater or less thickness become overheated, and this causes excessive expansion of the sheets. This constant movement of the fire box while the shell of the boiler is comparatively rigid, the two being firmly riveted together at the foundation ring, all movements of the fire box must be accommodated by the stay-bolts and the importance of flexibility in the stay-bolts has been recognized as an absolute necessity. A great many roads have tried the expedient of reducing the diameter of the stay-bolts in the water space; others have milled out the stay-bolt longitudinally in the water space, and while these and similar attempts have accomplished some good, the urgent necessity for something more flexible and durable has been felt to be a necessity by the motive-power department of our railroads, especially in those sections using bad water. It has been observed that about ninety-nine per cent. of all stay-bolts which break give way just inside of the outer sheets; this being fully recognized by locomotive builders and locomotive superintendents, it has become an almost universal practice to drill a small hole in the outer end of each stay-bolt for the purpose of detecting broken stay-bolts. While this has worked satisfactorily in soft water districts, it has been the experience of

motive-power men in bad water districts, that, after the stay-bolts have become partially broken, the fracture extending from the outer surface to this small hole drilled in the stay-bolt, the lime and other scaling matter contained in the water, works its way into the hole, so completely stopping it up as to prevent any escape of steam or water. In such cases the method of detecting broken stay-bolts is by the insertion of a steel wire or other suitable pointed instrument into the detecter holes.

Many theories have been advanced as an explanation for the breaking of stay-bolts, and as to the cause of their breaking invariably next to the outside sheet. It is conceded that the expansion and contraction of the fire-box sheets is principally responsible for the fracture of the stay-bolts—due to the repeated change in position of the fire-box.

This same action goes on in the fire-box of every locomotive, whether the water used is what is known as soft water or hard water, and it has been somewhat of a puzzle to account for the much larger number of broken stay-bolts in those engines using hard water.

The following explanation has been suggested as the true cause of this trouble, where hard water is used: In the first place, scale forms more rapidly on the fire-box sheets; the sheets become much hotter, and the expansion is much greater than where no scale is formed.

These strains brought upon the stay-bolts due to the expansion and the contraction of the sheets, open the fibre of the metal in the stay-bolts near the outer shell of the boiler, and a thin film of scale is immediately deposited, and when the stay-bolts are forced in

the opposite direction, this film of scale, occupying the space, offers resistance to the fibre of the metal resuming its normal position. In the meanwhile scale is deposited in the open fibre of the metal on opposite side of staybolt, and as this process continues, the film of scale being deposited in this ever increasing opening has the effect of wedging the metal apart alternately on one side and then on the other, finally causing the staybolt to part at that point. The stay bolt does not break next to the fire box sheet. Due to the fact that this end of the bolt is kept at such a temperature that the metal is more elastic and yields to the change of position without opening the fibre and exposing it to the entrance of this deposit of scale.

To overcome this difficulty many other mechanical devices have been designed, one of which is known as the Tate flexible staybolt.

It will be seen by reference to Fig. 1 that this device is composed of three parts, namely, the bolt, sleeve and cap. The cap is made of drop forged steel, the sleeve of cold rolled steel and the forged bolt of fibrous wrought iron, staybolt quality.

The method of applying this staybolt is as follows: In applying flexible staybolts covering large areas, it is advisable to gag the sheets, or hold same together, by screwing a stud through the tapped holes, locating such every four or five rows, and so spaced to prevent the springing in or out of the sheets when being machined or when bolts are being riveted over.

The most essential feature in installing the staybolt is the operation of machining the outer plate of boiler for the fitting of the Tate Sleeves. Each hole drilled and taper reamed should be as round as possible and so preserved under process of tap-

ping; and taps should be well oiled and in good order.

Taps and reamers should be kept sharp, and the instant tap threads become rounded, such should be dispensed with until reground or replaced, for perfect threads can only be maintained by keeping the taps ground sharp in the cutting face of flutes.

Depth of reaming and tapping should be carefully gauged to the proper size hole.

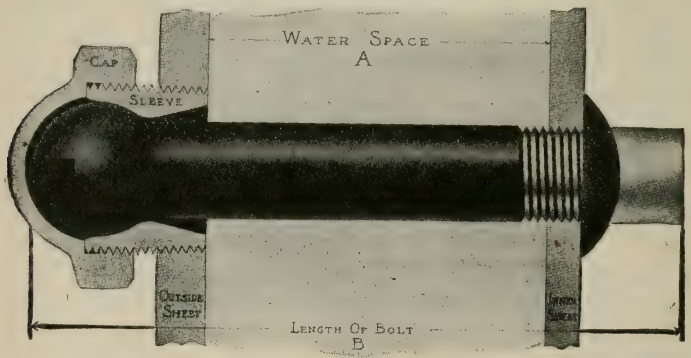


Fig. 1.
Tate Flexible Staybolt.

A small section of boiler plate should be drilled, reamed and tapped to gauge, so that a sleeve when screwed in tight comes flush with inner surface of plate, and with holes drilled, reamed and tapped, respectively, in same plate; this specimen of tooled plate will readily serve as a reference to set gauges for reamer and tap for the sleeve used.

If a tap follows an oval hole, the tendency would be to wobble the tap to fill the threads, and thereby a condition is produced which is most difficult to

correct without recourse to calking to obtain a steam tight fit when the Tate Sleeve is installed, and if a wobbling tapping operation follows a round reamed hole, a like condition is presented.

An oval reamed hole is due largely to the weight of the pneumatic drill, or machine drill, bearing down when held in position by operators. These machines should be counter weighted by rope or chain suspended above, or the machine supported in fixed position by the use of adjustable frame work.

After the holes are tapped, detach the thin burr left by tap on face of plate surrounding hole, clean out hole, and brush the sleeve threads with graphite mixed thin in good cylinder oil, screw in sleeve with a three-foot wrench, using stud nut, until tightness of screwing determines a joint.

Tapping the inner sheet in perfect alignment with hole of outer sheet is essential to the proper assemblage of the bolt, and if the threading of the inner sheet is done after sleeve has been applied to outer sheet, use a bush over sleeve to support staybolt tap and prevent the threads from cutting the sleeve.

The face of sleeves where cap screws down and makes a joint should be protected from burrs, jams, etc., throughout shop handling and riveting up of bolt. The bolt is then screwed into place by means of a bolt driver which fits in the head of the bolt.

Graphite and cylinder oil mixed thin should be applied to the threads of the caps, to insure easy removal when such is necessary, which are put on after the riveting is completed.

The practice adopted by one large railroad in renewing old staybolts of the ordinary form and

replacing them with flexible bolts, is as follows: The outer end of the staybolt is drilled through the outer sheet with a 1⅝-inch twist drill. A piece of gas pipe is then inserted through the water space, so that the old staybolt to be removed is inside of the pipe; the staybolt is then cut out or drilled out of the inside sheet, and is knocked out through the pipe. This prevents it from falling into the water leg of the boiler. The outer sheet is then tapped out, pieces of gas pipe or suitable mandrel passing through the tap or through the inner sheet of the fire box, guiding the tap. The fire box sheet is tapped out in the usual way. All of this work is done by the use of pneumatic tools, and is thus rapidly performed.

Federal Stay-Bolt Testing.—It has become a law that all rigid staybolt and all flexible staybolts which do not have caps shall be tested at least once each month. Flexible staybolts with caps over the outer ends shall have caps removed at least once each eighteen months in order to thoroughly inspect the staybolt. Fire box sheets should be examined carefully at least once a month to detect any bulging or indication of broken staybolts. Telltale holes are required in all staybolts shorter than 8 inches except in flexible staybolts.

LOCOMOTIVE ECCENTRICS.

The reason the eccentrics of a locomotive should be considered of great interest to the practical railroad man is perhaps not difficult to explain, if we take into consideration the frequent delays due therefrom, and the fact that there are, at least, four of them on every locomotive equipped with Stephenson (or similar) valve motion, that they are of great size and weight, and that their speed is the highest at times when inspection is impossible until some stopping point is reached. While they should be provided with a set-feed oil cup (besides the usual oil hole filled with hair or wool), still on the locomotive they are not readily accessible and can only be well inspected by getting under the engine in the roundhouse.

The accompanying engraving of Linstrom's improved eccentric for locomotives will be of interest from the fact that it would seem to solve some of the difficulties attendant upon the usual construction of locomotive eccentrics.* The eccentric set screw is done away with, the U-shaped bolt *D* not only holding the two segments *A* and *B* together, but also clamping them to the shaft. While there is no objection to the use of keys with this eccentric, it is said to be unnecessary, as its construction prevents its slipping on the shaft. It is claimed to allay the running hot of the eccentric, which often occurs on the ordinary form, on account of tightening the set

*For illustrations and description of the ordinary locomotive eccentric, the reader is referred to another volume devoted to motive power.

screws and thereby forcing the eccentrics away from the shaft and causing them to bind in the straps, producing excessive friction.

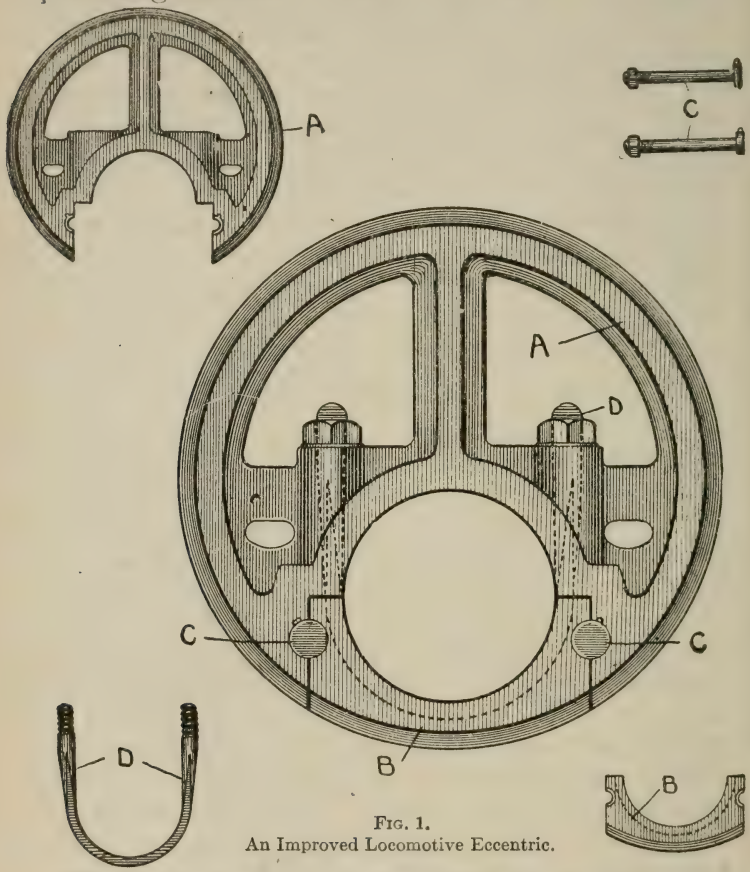


FIG. 1.
An Improved Locomotive Eccentric.

The two bolts *C C* serve as dowel pins to hold the two halves of the eccentric rigidly together, even if nuts on U-bolt *D* should become loosened.

The extensive use of eccentrics has been overcome by the more general use of an outside valve gear, such as the Walschaert, the Baker, etc.

ROD PACKING FOR LOCOMOTIVES.

In early locomotive practice all the glands and stuffing boxes were packed with hemp, cotton or other fibrous packing, occasionally some ingenious engineer buying a little tea-lead when he became too tired of renewing the packing almost daily. And it is perhaps this latter practice that furnished the idea of metallic packing now so generally used on valve stems and piston rods.

There still remains, however, a considerable number of locomotives, especially on logging or other

Rubber Wound Cloth Packing.

small railways not conveniently situated with reference to machine shops, where some kind of packing other than metallic is used on these parts; but instead of hemp or cotton, some of the forms shown in the accompanying illustration, as *A*, *C*, *K*, and *L*, being those most used. The packing here shown is made from layers of asbestos cloth or canvas coated with rubber. This makes a very strong and elastic packing, suitable for joints of all kinds. A mixture of

plumbago or graphite is often intermixed with the layers of cloth and rubber, and tends to reduce the friction to a considerable extent and insure greater life to the packing.

Many improved forms of fibrous packing are now in use for packing stationary glands, such as cab cocks, throttle, etc., and especially for valve stem packing on piston valve locomotives, where they have only exhaust pressure to withstand.

The first metallic packing for locomotives simply furnished metal rings in place of the fibrous ones formerly used. It failed to provide all the essentials that have since been found necessary to success.

Fibrous packing had at best more or less elasticity. It was possible to compress it between its gland and the bottom of the stuffing box enough to make it contract on the rod and make a joint. If the rod moved out of the center of the stuffing box when at work, it pushed the packing aside, and when it moved back its packing followed it or else there was a leak. Some means had to be provided to make the soft metal rings fit the rod and be free to move with it. They must fit tighter on the rod when the steam is on than when it is off.

The first improvement was in adopting a cone cup on the gland end of the packing and fitting the soft metal rings into it. These rings were kept into the cone by a spring. This kept the rings in contact with the rod, and the steam itself increased the pressure when the piston was doing work.

UNITED STATES METALLIC PACKING.

By reference to Figs. 1 and 2 it will be seen that this packing consists of three babbitt rings, numbered 2.

The parts referred to by number in these cuts are: 2—three babbitt rings, known as one ring; 3—flange follower; 4—ball joint; 5—swab holder; 6—vibrating cup; 7—gland; 8—preventer.

It will be seen that all the parts other than the babbitt rings are simply for the purpose of properly securing these in a steam-tight position against the piston rod, with the exception of the ball joint 4, which is to prevent the escape of steam from around the

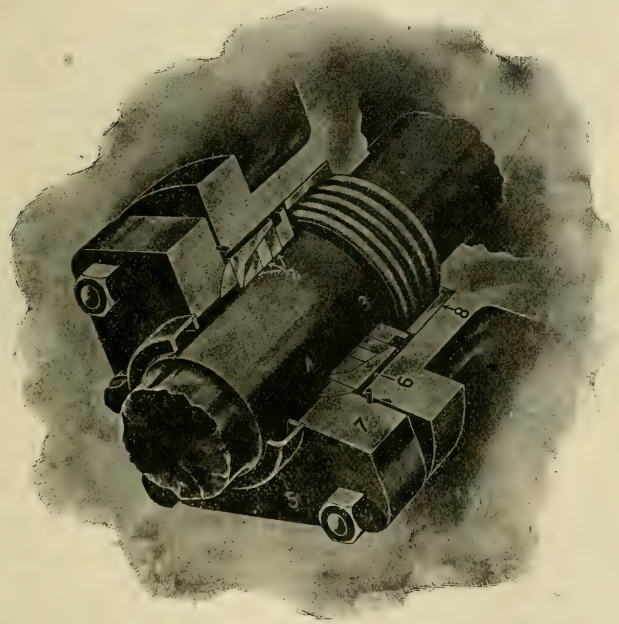


FIG. 1.
United States Piston Rod Packing.

packing. The babbitt rings 2 are made each in two halves in order to avoid the necessity of disconnecting the crosshead from the rod, and they are placed in a vibrating cup, 6, whose interior form is that of a double angle cone. The face of this cup 6 bears against the

flat face of the ball joint ring 4, which makes a joint with the outer casing or gland 7; the coil spring with its follower 3 and preventer 8 holds the whole in place when there is no steam pressure to do so, and thus prevents the rod from drawing them back. The soft

FIG 2

United States Piston Rod Packing for Pistons with Enlarged Ends.

babbitt rings 2 are the only parts that should touch the rod, so that if the rod is once trued up perfectly round and parallel it should wear very slightly and evenly.

As most modern designers make piston rods with enlarged ends, Fig. 2 will show the provisions made

therefor, namely: the flange follower 3 and the vibrating cup 6 are composed of two rings, the inside one of which in each case is made in two halves.

This packing should always be lubricated by an oil cup supplying oil to a swab cup.

Fig. 3 shows the Gibbs vibrating cup, designed for engines having an enlarged end on rod. It is recommended as an improvement over the regular vibrating cup for this purpose. This cup has an inner ring, in halves. In designing new work, using this cup, it is desirable to increase the diameter of stuffing box one-half of an inch.

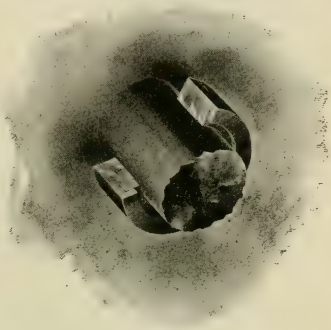


FIG. 3.
Gibbs' Vibrating Cup for Pistons with Enlarged Ends.

UNITED STATES VALVE-STEM PACKING.

It will be seen by reference to Fig. 4 that this packing is very similar to the piston packing of the same manufacture. A bushing or support, 9, is placed in the stuffing box to carry the weight of the valve stem. This support wears the valve stem less than the neck of the cylinder head formerly did, yet it is certain to wear some flat place on the under side of the valve stem the length of the valve travel when the reverse lever is hooked up in the position most used. Then when the valve is full stroked this flat place would travel farther into the packing rings, and cause

a bad leak. This has been overcome in the design of this packing, by the use of the long, extended gland 7 and preventer 8, which render the distance between the support 9 and the babbitt rings 2 slightly greater than the full valve travel.

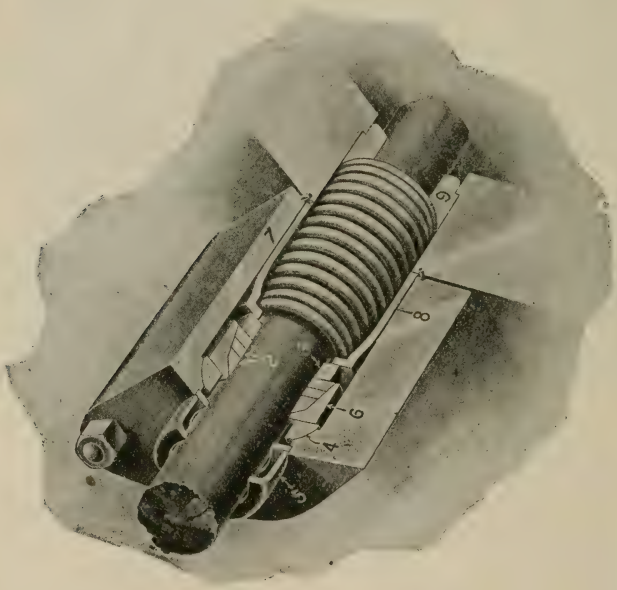


FIG. 4.
United States Valve Stem Packing.

Parts referred to by numbers, in Fig. 4, are as follows: 2—three babbitt rings in halves, known as one ring; 3—follower; 4—ball joint; 5—swab cup; 6—vibrating cup; 7—gland; 8—preventer; 9—support.

JEROME METALLIC PACKING.

Fig. 1 represents the Jerome piston rod packing, embracing all the new improvements used therewith. The parts designated by letter are: A--piston rod; B--the cone; C--the gland; D--the stuffing box; E--the packing rings; F--the follower; G--the coil spring; H--the bushing ring; J--stud bolts; K--sliding ground joint; L--cap screws, to hold the swab

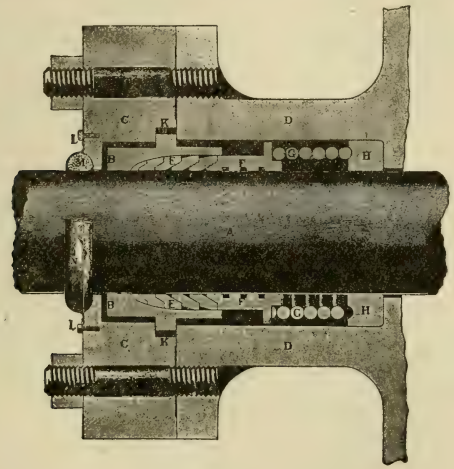


FIG. 1.
Jerome Piston Rod Packing.

holder; N--swab holder; M--the swab. The swab holder N is one of the best devices for oiling the piston rod and valve stem of an engine yet invented, and is now applied to all of the Jerome packing.

Fig. 2 shows in detail the Jerome standard piston packing for rods with enlarged ends. *B* represents the gland; *C*, the rear portion of the cone which is

ground to a joint in the gland *B*; *D*, the outer portion of the cone or packing case, which is made in halves,

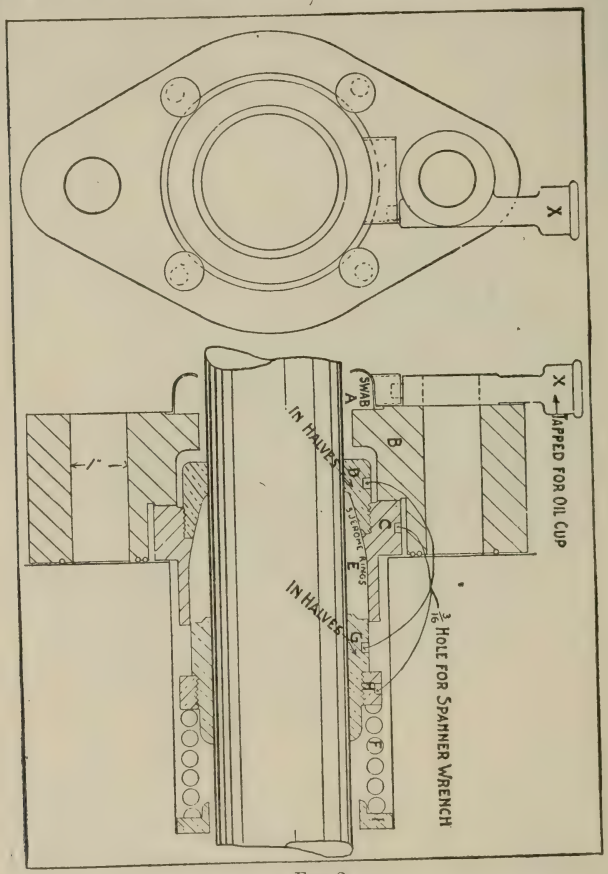


Fig. 2.
Jerome Piston Rod Packing for Pistons with Enlarged Ends.

of gun metal, and fitted with dowel pins to hold it rigidly in place when applied. The two halves of *D*

are held together by *C* screwing over them. *E* shows the space where the packing rings shown in Fig. 1 are to go; *F* is a coil spring; *G* is a follower, which is also made in halves and held in place by the ring *H*, which screws over it from the inside; *I* is a ring placed in the bottom of the stuffing box, where it cannot rub on the rod, and is used to make a seat for the spring *F*; *X* is a pipe, or tube, leading to the swab, and *A* is the oil cup, fed from the pipe *X*, which screws into it.

When desired, cone *C* is made in two parts, the outer ring being in the form of a ball joint, but in most cases this is said to be unnecessary.

Fig. 3. Packing Rings for Jerome Piston Rod Packing.

After the piston rods have become worn and are turned down, it is only necessary to make a smaller cone, *D*, and reduce the size of the packing rings by cutting out a portion of each ring, so that it will close upon the smaller rod.

The babbitt packing rings used in this packing are each partly severed, as shown in Fig. 3, which represents a set of rings with one ring above opened in open position, ready to close around the rod without the necessity of disconnecting the rod from the crosshead. As the packing wears it ordinarily only requires the addition of another of the larger rings.

JEROME VALVE-STEM PACKING.

Fig. 4 shows in a similar manner the application of Jerome metallic packing to a valve stem. It will be seen that the cone *D*, or vibrating cup, has a straight sliding joint at *C* to compensate for any lateral play

in the valve stem. This is found to be satisfactory, except where there is a great deal of rolling motion, due to the valve stem being very short, in which case a

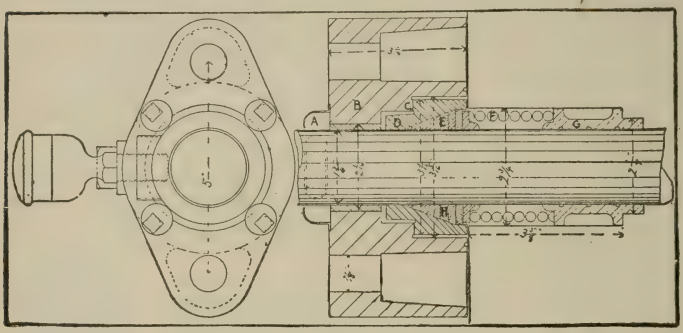


FIG. 4.
Jerome Valve Stem Packing.

ball joint is made at *C* by the addition of another ring, as before described for piston packing where desirable.

When the valve stem wears or is turned down, it is

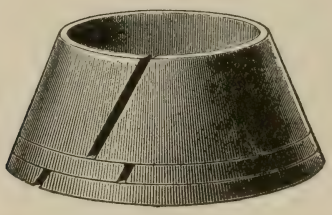
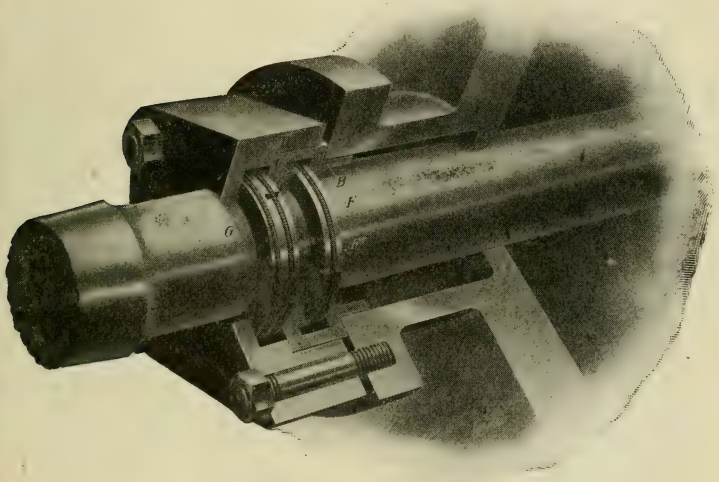


FIG 5.
Jerome Valve Stem Packing Rings.

only required to make a smaller cone *D*, and add new packing rings.

Fig. 5 shows the babbit rings for one valve stem,

turned up to proper size, ready for application. In case it is not convenient to disconnect the valve stem, the rings may be sawed in half, and applied in this manner. In applying new rings to either the piston rods or valve stems, be sure that all joints are properly broken.



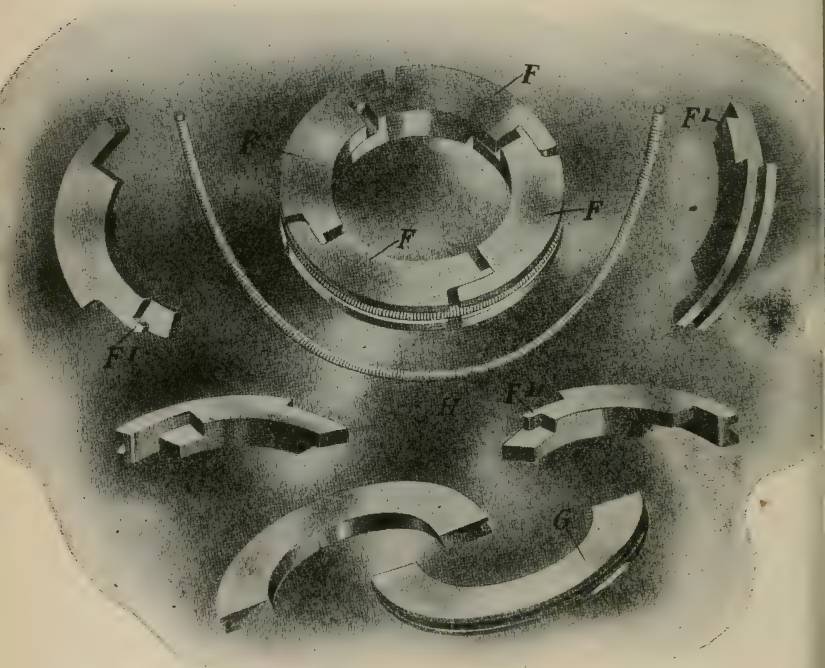
L. & K. Packing Applied to Piston Rod

A—Back Cylinder Head.
B—Stuffing Box Bushing.
C—L-Ring, forming grooves for packing.
D—Gland.
F—Packing Segments
F-1—Feeding tongues on packing segments.
G—Split cast-iron re-enforcing ring.

L. & K. METALLIC PACKING

This is a packing which in design, workmanship and material possesses great longevity, produces little friction, yet forms a perfect joint between itself and the rods, and is not affected by a high degree of heat or speed.

The gland used with the L & K packing is made entirely of cast iron and consists of five parts as follows: Stuffing box bushing B; L-ring C, which forms the grooves; outside gland D, and two split cast iron re-enforcing rings G, held together by steel retaining springs H.



L. & K. Packing Rings

Parts B, C and D are bored ½ inch larger diameter than the full size of piston rod, which allows them to pass over any enlarged crosshead fit up to that size.

The re-enforcing rings G have nothing to do with making a steam tight joint, their only office, as their name implies, is to prevent the steam pressure from forcing the soft packing

rings through the opening between the piston rod and the bore of parts C and D. Accordingly the re-enforcing rings are bored 1/32 inch larger than the rod, to prevent scoring it.

The grooves for holding the metallic packing and re-enforcing rings are formed by the L-ring C, the outside face of B and the inside face of D. These faces are smooth finished, making steam tight joints when the gland is in position. To allow the packing rings to follow any vibratory motion of the piston rod, due to faulty alignment or wear of the crosshead, the diameters of the grooves are ⅝ inch and the width 1/32 inch larger than the corresponding dimensions of the packing rings.

The joint between A and B is made steam tight by means of annealed copper wire imbedded one-half its diameter in part B.

The packing rings F are made of white metal of special composition, and are generally two in number, consisting of four or more segmental pieces, each having broken joints arranged in such a manner that they form steam tight rings when under pressure. Each segment has a feeding tongue F^1, which wears off as the packing closes up on the rod.

The segments F forming a ring, are held in position by the retaining spring H, which, however, does not aid in making a steam tight joint on the rod.

VALVE STEM PARTS

By comparing the two cuts, it will be noted that the locomotive valve stem and piston rod packing do not differ in any material respect.

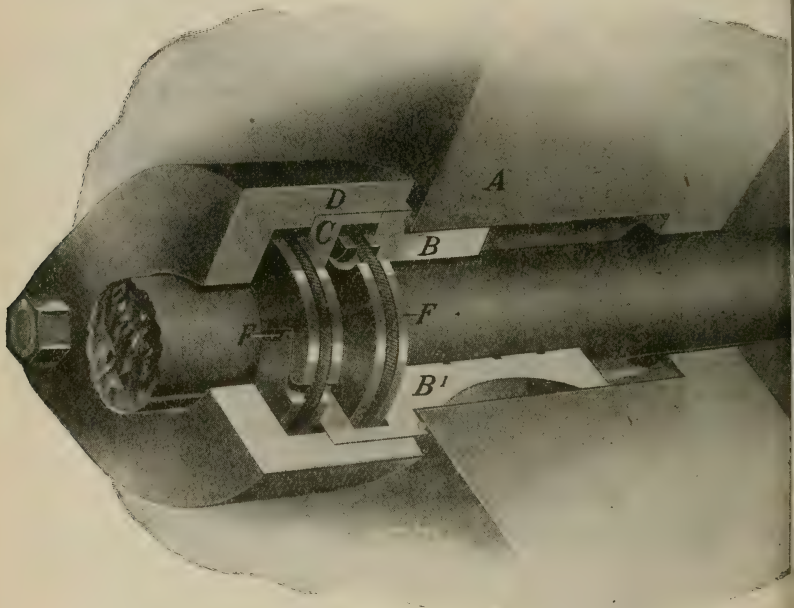
When applied to a slide valve, the stuffing box bushing B^1 is made of bronze and supports the weight of the stem and yoke, at the same time acting as a guide for the rod; for piston valves, the bushing B is made of cast iron.

For valve stems, the re-enforcing rings are not necessary as there is no enlargement of the rod, and accordingly the parts B, C and D are bored only ⅛ inch larger than the valve stem.

General Information—Unlike most forms of packing, no heavy coil spring is used to secure a steam tight joint between

the packing rings and the piston. This packing depends entirely upon the steam pressure to make tight joints, and for this reason, there is practically no friction on the rod when the engine is not working steam.

When under steam pressure, the rings are forced tight against the outer wall of their respective grooves, and the



L. & K. Packing Applied to Valve Stem

steam also presses the segments tightly upon the rod, thereby forming a steam tight joint.

In service, the segments close up along a plane parallel to the circumference of the rod, and hence the packing remains steam tight until the segments have closed up entirely, due to wear. After this has occurred, the packing rings should be renewed.

Packing rings are sent from factory assembled, bored to exact size of rods and ready for application, no further machining or work being needed.

Should it be desired by the consumer to bore rings, it is necessary to use a special chuck. To avoid the necessity of carrying a large stock of various sizes of packings, the rings are cast with enough material to be bored to fit sizes within a quarter of an inch; for example—the same size of ring can be used for packing rods from $2\frac{13}{16}$ inches to 3 inches in diameter, the next size ring can be used for packing rods from $3\frac{1}{16}$ inches to $3\frac{1}{4}$ inches in diameter, etc.

MITCHELL METALLIC PACKING

All metallic packings usually pack the newly turned rod, but are apt to fail to repack the rod when worn. The effect

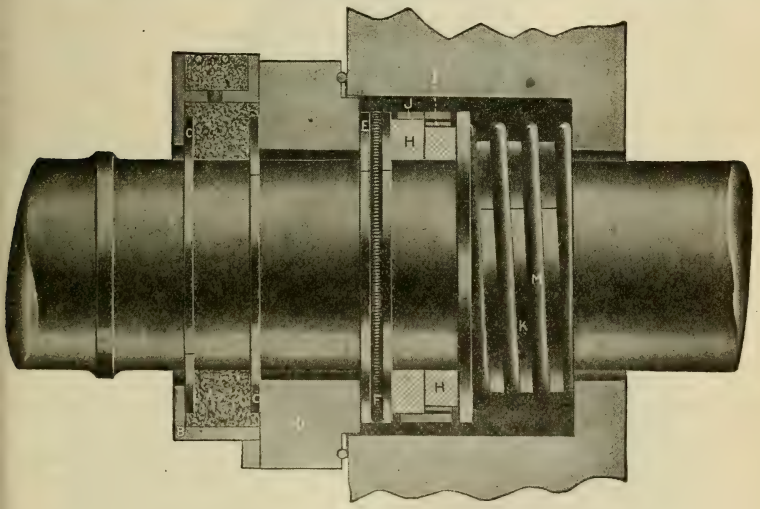


Fig. 1.—Mitchell Metallic Piston Rod Packing.

A—Oil Cup.
B—Swab Cup.
C—Swab Cup Disc.
D—Piston Rod Gland.
E—Split Joint Ring.
F—Retaining Coil Spring.
H—Babbitt Segments.
I—Supplemental Spring.
J—Retaining Ring.
K—Split Follower.
M—Coil Spring.

of metallic packing on the rod is usually to wear the latter oval midway of its travel; hence, the necessity of having a packing capable of conforming to any variation from an oval to a true circle. When a rod is worn by this packing, it is claimed that the rod can be packed as successfully with the replacement packing as by the original.

The great problem is to successfully pack superheated engines, especially those equipped with the Schmidt superheaters. This packing is especially effective in packing rods of engines equipped with Schmidt superheaters. For this purpose the packing segments are composed of half copper and half lead and will stand 1200 degrees Fahrenheit and do

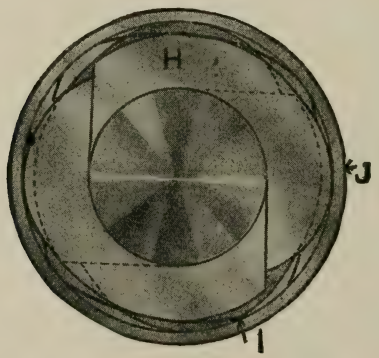


Fig. 2
Applied Segments—Mitchell Metallic Packing

not wear the rod any faster than soft metals on saturated engines. The great advantage claimed for this packing over other makes, is that it acts as a floating washer and has no cone ends to crumble off under the high heat of the superheated engine. It has been demonstrated that it is necessary to use a high copper mixture for packing segments to be used on superheated engines and as copper becomes extremely brittle under high heat, it is held that this form of application to the rod best protects it from breaking.

Fig. 3
Babbitt Segments—Mitchell Metallic Packing

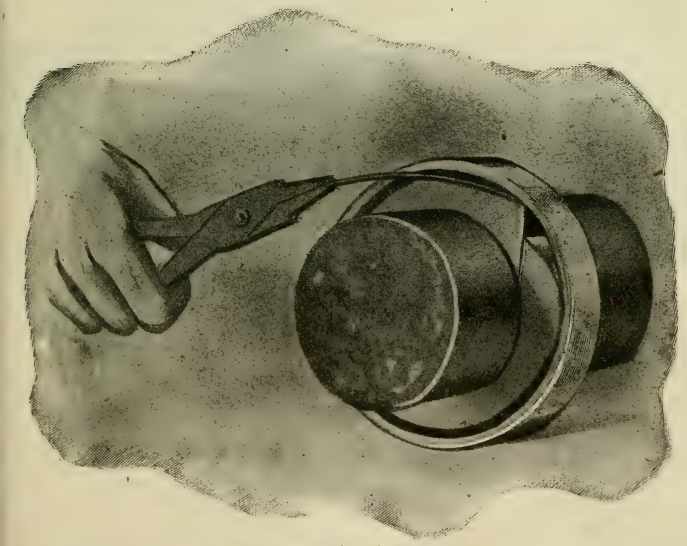


Fig. 4
Method of Applying Supplemental Springs—Mitchell Metallic Packing

DIRECTIONS FOR APPLYING—1. Do not apply packing to rods that are cut or scored.

2. Packing may be applied to rods that are worn smooth and oval when not worn to exceed 1/64 per diametrical inch of the original diameter.

3. Bore packing 1/128 of an inch larger than the largest diameter of the rod.

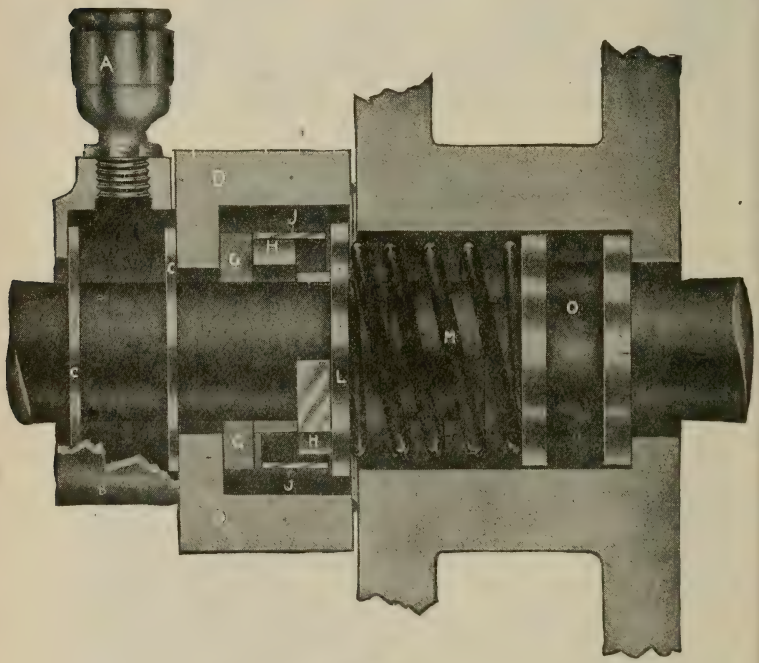


Fig. 5
Mitchell Metallic Valve Stem Packing

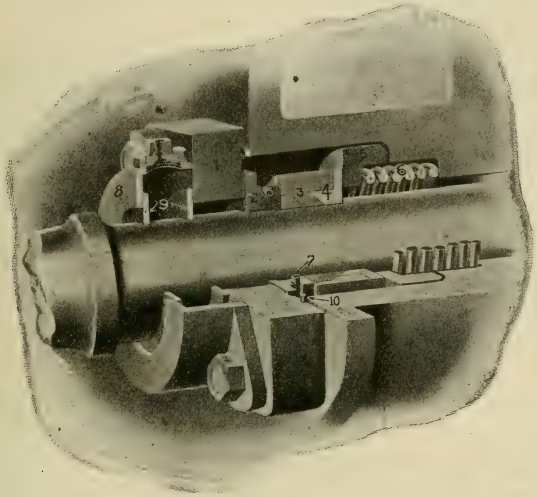
A—Oil Cup.
B—Swab Cup.
C—Swab Cup Disc.
D—Gland.
G—Joint Ring.
H—Babbitt Segments.
I—Supplemental Spring.
J—Retaining Ring.
L—Follower.
M—Coil Spring.
O—Guide Bushing.

4. The underlying ends of the segments of both packing rings should point in the same direction, either to the right or left and joints should be quartered as shown in Fig. 2.

5. Under no circumstances should the joint ends of the segments be filed or reduced.

6. Joint rings should be ground joint against gland.

7. Followers and joint rings should be mated by numbers as marked on these parts.



8. Split followers should be firmly held together by the coil spring.

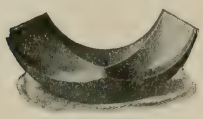
9. Coil springs when compressed should exert the following pressure: Against packing 1½-inch rod, 45 lbs.; 2-inch rod, 55 lbs.; 2½-inch rod, 65 lbs.; 3-inch rod, 80 lbs.; 3½-inch rod, 85 lbs.; 4-inch rod, 100 lbs.; 4½-inch rod, 110 lbs.

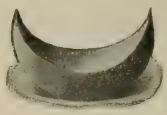
CRESCENT METALLIC PACKING

From the illustrations it will be noted that this packing has no ball joint or vibrating cup, both of which parts

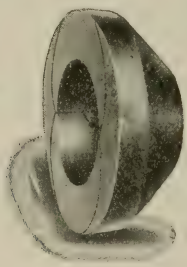
are used generally with standard metallic packing, and, it is claimed, are the cause of the greater part of the steam leaks.

The form of the Crescent white metal segments needs no





vibrating cup, but simply a retainer to hold them in position, and it is not necessary that this retainer be a close fit to the rod as is usually the case. The shape of the white metal segment permits of practically all the metal being used up



before a new set of packing segments are required, whereas with most metal packing rings they are reduced less than twenty per cent in weight when worn out.

AIR PUMP METALLIC PACKING.

As the air brake is now almost wholly relied upon to handle trains—both passenger and freight—a failure to obtain sufficient air pressure usually results in serious delays to trains, as well as rendering their operation less safe.

Air pumps are one of the hardest things to pack well with fibrous packing, and yet one of the easiest to pack with metallic packing. Several large railroads use shot and graphite, which in time hardens into a state similar to babbitt packing; many other railroads use a metallic packing of their own design; hence it will suffice to here show the two forms of metallic air pump packing most frequently used when purchased from manufacturers.

UNITED STATES AIR PUMP PACKING.

This form of packing is shown in Fig. 1 as applied to the regular stuffing box standard to air pumps. It should be noted that the cone is made enough smaller than the stuffing box to allow some vibration. The cone also has a shoulder fitting over the stuffing

box, thereby preventing the gland being screwed in far enough to close up the coil spring.

The form of the babbitt rings is seen to be quite

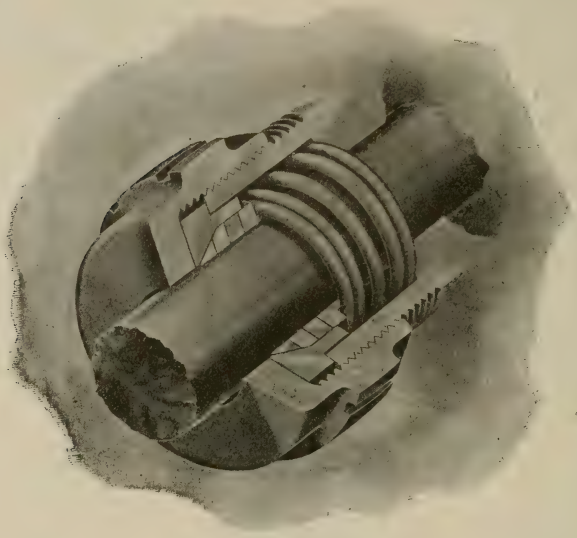


FIG. 1.

United States Air Pump Packing.

similar to those furnished for piston rods and valve stems by the same manufacturers.

JEROME AIR PUMP PACKING.

This form of metallic air pump packing is shown in Fig. 2, which clearly illustrates its use.

No air pump should be used on a locomotive without some form of metallic packing, as it is much less likely to burn out than fibrous packing, and will thus prevent many a delay or engine failure.

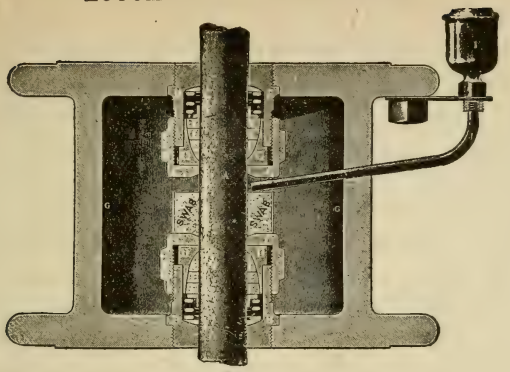


FIG. 2.
Jerome Air Pump Packing.

SWAB HOLDERS.

It should be remembered that metallic packing is a babbitted bearing and needs oil and attention just as much as it would if the shaft turned around.

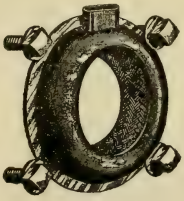


FIG. A.
Swab Holder and Swab for Lubricating Valve Stems and Piston Rods.

The engraving shows a not uncommon form of swab holder and swab used on piston rods and valve stems. The air pump packing needs a swab no less, and is very easy of application by any engineer. Any engineer can bend a piece of copper or sheet iron, wind with candle wicking, and in short order have a very effective air pump swab.

LOCOMOTIVE LUBRICATION.

Next in importance to the proper design of the various parts of a locomotive may be considered the care and lubrication of the many bearings, pins, etc., where movement between the parts takes place.

It is needless here to enumerate these parts; suffice it to say that all locomotives use cylinder oil and some grade of machine oil (usually termed "engine" oil). A cheaper grade of machine oil, termed "car" oil, and some form of solid or pasty grease are also employed as lubricants on many classes of locomotives.

To properly distribute these different grades of lubricants, we will consider first the locomotive lubricator, not only on account of its great relative importance, but because of its embodiment of the greatest ingenuity, subsequently illustrating and describing many of the various styles of oil and grease cups used upon the bearings and pins not surrounded by and subjected to the heat and pressure of steam.*

THE LOCOMOTIVE LUBRICATOR

Although many engines (notably marine engines using distilled feed water) have been run successfully without cylinder lubrication other than that of the steam that is condensed about the walls of the chamber, as higher boiler pressure became used in locomotive practice, it was found advisable to employ oil in the lubrication of the cylinders.

*In another volume the reader will find many valuable points of information relative to the proper lubrication of locomotives.

The boiler of a locomotive is probably forced more at times and more steam is taken from it in a given time than from that of any other boiler of the same size. This causes priming, and more or less of the water is carried with the steam into the cylinders. Hence, if the water has much of any incrustating matter in solution, much of it reaches the valves and valve seats, the pistons and cylinders, and results in cutting these surfaces to a considerable extent, even with the most approved methods of lubrication.

The original method employed for oiling the valves and cylinders was by means of an oil cup located on top of the steam chest, through which cup oil could be supplied to the valves and cylinders below whenever steam was shut off.

This necessitated the engineer or fireman going to the front end of the engine and pouring oil in these two cups—one on either side. This was neither convenient nor always safe. About the year 1864 the next improvement made was in the placing of these oil cups in the cab and connecting them by sloping pipes to either steam chest. Thus the oil could be supplied by the enginemen without their leaving the cab.

After many designs of hand oilers had been used, the necessity for an even flow of oil to valves and cylinders of locomotives was met in the year 1872 by the introduction of the steam-chest oiler that could be filled, and an adjustment made whereby a constant and controllable flow of oil was had.

In 1883 the first *down drop-feed* lubricator made its appearance, one being provided for each cylinder These lubricators were located in the cab with pipes leading to each steam chest.

In 1885 this was changed to the *up drop-feed*, one lubricator for each cylinder being used, however, until 1886, when the *double sight-feed* lubricator was put in use. From the time of the introduction of the air brake and consequent use of the air pump up to 1888 a separate lubricator was used for air pump lubrication. In that year, however, another feed attachment was added to the cylinder lubricator for this latter purpose, making it a *triple sight-feed* lubricator, as at present used, several varieties of which it is the purpose of this chapter to illustrate and describe.

With the adoption of superheated steam on locomotives, many railroads desired additional lubricator feeds direct to the cylinders; hence the advent of the *five-feed* lubricators.

With the high pressure of steam, now quite general in modern locomotives, there has been in some instances a disturbing element developed in valve oiling, which, with reason, excites the attention of enginemen and others interested therein. It has been demonstrated that, with a high steam pressure and a cut-off of one-quarter or less, there is a holding of oil within the oil pipes in case the locomotive is worked with wide open throttle. How much of this withholding of oil is due to an improper supply of steam to the lubricator, and how much to improper arrangement of oil pipes, over which the lubricator manufacturers have no direct control, is a matter of considerable speculation.

Any change decreasing the size of pipes or of their location, preventing a free flow of oil along the pipes in a constant and downward course by an upward

turn of current or by bad bends in the pipe, will surely pocket the oil and hold it back until the strength of the draft at the steam chest outlet increases sufficiently to overcome it. Decreasing the pipe opening at any one point between or at the steam inlet valve on the boiler and the oil outlet at the steam chest will doubtless pocket the oil.

With the original sight-feed lubricators and a boiler pressure of 130 pounds or less there was no trouble experienced in connecting up with piping 5-16 inch inside diameter. A change to higher pressures, with complaints of trouble in their proper lubrication, has induced the majority of makers to advise the use of pipe having an inside diameter of not less than ½ inch, and to issue explicit instructions as to the manner of applying the steam and oil pipes. It is a well known fact that, next to initial condensation of steam, friction causes the greatest loss of power that occurs in the steam engine. The idea of employing sight-feed lubricators is not faulty, as these instruments are the fruits of a vast amount of study and experiment, and they are very successful in performing their duty of delivering regularly a small amount of lubricant, which may be nicely controlled. The trouble is probably outside of the lubricator, and lies in the method of sending the oil to the steam chest; it lies in the pipe system employed, through which the oil is expected to pass in a downward sloping course from the lubricator to a point six or seven feet below it to the steam chest. The oil feeds well enough when the throttle is closed and it is aided by a vacuum in the steam chest, and the difficulty begins when the throttle is opened and

steam, but little lower than boiler pressure, is admitted at the steam chest end of the pipe.

The results are more noticeable and more troublesome with high pressures, which are used to assist in meeting the vastly increased duty expected of modern locomotives, but it is not believed to be true that the high boiler pressures cause the lack of regular feeding of oil to the steam chest. Accompanying the use of increased pressures, longer locomotive runs are now the rule, which makes it more important to lubricate properly. The complaint was also made by engineers that the valves used the oil, and the cylinders did not get enough. The reason that the oil does not go through the pipes regularly is interesting. It is reasonable to suppose that, at the opening of the throttle, steam under or very near boiler pressure is forced up into the long oil pipes, where it condenses, nearly filling the pipes with water, and the lighter oil cannot get through the water under these conditions. Some of it may get through on account of the churning it receives.

Engines working slow and hard with long cut off will get their oil all right as the steam chest pressure will fluctuate with the opening of the ports by the valve, in which case the boiler pressure will force the oil down. It must be understood that boiler pressure must be maintained on the lubricator for good results, and hence the aforesaid recommendations regarding the piping of lubricators are strongly urged.

Location of sight-feed lubricators.—The best location for the lubricator to secure good results will largely depend on style of boiler, and on location of other cab fittings. On engines with large foot plate, prob-

ably the best location is over the middle end of boiler. In this position the feeds are in plain view of both engine men, and irregular working and stoppage will be noticed at once. Upon engines, where the boiler extends well into or through the cab and the engineer's seat is at the side of the boiler, the cup should be placed with the cylinder feed glasses in line (lengthwise) with the boiler, with air pump feed and oil glass facing the engineer. This arrangement brings the feed glasses under the supervision of the engineer at all times in daylight, and by placing the gauge light on the same standard that holds the lubricator, it will bring the feeds out distinctly at night. The bracket supporting the lubricator should be sufficiently heavy to prevent vibration of the cup, this action tending to loosening of pipes and joints.

Steam supply and piping.—It has been the general practice to attach the steam connection for the lubricator to the turret, where a turret is used. In a number of instances, where the lubricator was not working satisfactorily, it was found that the dry pipe, supplying the combination stand, was not sufficiently large to supply all drains made upon it, and to maintain full boiler pressure in the lubricator. In cases of this kind it will be found beneficial to change the steam connection to the highest point of the boiler in the cab and, if necessary, to use a separate pipe for dry steam. Full ½-inch openings in pipes and fittings should be had to secure best results. It is also very important to see that the oil delivery pipe should have a good steady fall from the lubricator to the steam chest. Oil will float upward

through water, but not downward. Do not connect to turrets, as the pressure is not uniform when so connected.

Cleaning.—In cleaning out the lubricator, it will be necessary to occasionally immerse it in a lye bath.

This is especially true when care is not taken to strain oil. Some grades of oil leave a residue behind that, under the high temperature, seems to bake into scale. A practice of blowing out by steam tends to prevent this accumulation, but will not always remove it after it has once been formed. This will also be apparent on the glasses, and can be avoided and removed by a small amount of glycerine swabbed through the glasses.

Filling.—The greatest care should be exercised in the filling of the oil tank to prevent foreign matter of any kind passing into the reservoir with the oil, as the passages for same in all lubricators in use are very small (about 1-32 inch opening), and a small particle in the right place stops the feed and prevents the cup from working, on whichever side it may occur, until removed. To obviate this difficulty, it is recommended that all filling cans be provided with a strainer, believing that in this case an ounce of prevention is worth a pound of cure. With some makes of lubricator, it will be found best not to fill the oil tank entirely full, as there is a likelihood of a small quantity being forced over into the boiler, this action being brought about by the expansion of the oil in the reservoir.

When the principle of the lubricator is thoroughly understood by engine men, defects and peculiar actions will be easily detected and remedied. Partic-

ular attention should be paid to the matter of opening steam and water valves immediately after filling the oil tank, the opening of the water valve to avoid bulging of the oil reservoir and bursting of glasses, due to expansion of oil when heated. The steam valve should always be opened full to maintain as nearly as possible the boiler pressure in the lubricator all the time, whether steam is shut off from the cylinder or not. The steam valve should always be opened first, and closed last. By so doing, it will be found that nearly all of the trouble will disappear, as there will be no muddying up of water in sight-feed glasses, no siphoning of oil, and no irregular feed, for the equalization of pressures will protect the lubricator against those things---provided, of course, the lubricator is in working order.

If the sight-feeds get stopped up, shut the water valve at back of cup between condenser and oil tank, open the drain cock at bottom of cup, and the steam pressure will blow everything in the sight-feed glass up into the oil tank, carrying the obstruction out with it. In the same way the steam feed or chokes can be cleaned. In this case, shut the steam feed from the boiler and open the throttle, so the steam chest pressure will come into the cup. This will blow the obstruction in the choke down into the sight-feed glass, and leave this passage clear. In case of a broken feed glass close the valves above and below the break; use hand oiler until such time as new glass can be put in. Proceed as follows: Close water valve; then steam valve. Take off packing nuts on broken glass, unscrew box of the valve on top of the feed arm, where glass is broken,

drop glass in from top through packing nuts, using new gaskets. Do not tighten packing nuts too tight, replace valve box on top of upper feed arm and open steam valve, and when glass fills with condensation open water valve.

Equalizing feature.—The successful working of the modern lubricator as applied to locomotives of to-day is almost entirely dependent on the equalizing feature. It will be found that in the majority of cases of irregular action this feature has been destroyed, either by insufficient opening from boiler to lubricator, equalizing pipes partially or wholly stopped up, or choke plugs worn larger, or becoming loose. The opening in choke plugs should bear a certain relation to the amount of steam delivered through the equalizing pipe, in order to hold up boiler pressure in upper feed arm. As one writer has said: "On account of small opening in choke plug the steam is huddled up, and not allowed to pass out freely into the oil pipe, whereby a pressure equal to the full boiler pressure is maintained on top of sight-feed glasses, irrespective of whatever pressure may or may not prevail on the opposite or cylinder side of the choke plug." It will be apparent, from what has been said, that the feed will be regular, irrespective of pressure in oil pipes, as this equalization of pressures in the lubricator is brought about by reducing the opening at the point of oil delivery. This is especially true where full throttle and short cut-off is used. When throttle is opened wide in starting, the oil pipes fill up from the steam chest end first. If the engine is cut back, the steam chest pressure is very nearly the same as the lubricator pressure, and the current of oil and steam

through the chokes is very slow, no doubt being delayed sometimes several minutes or until such time as the throttle is eased off. Reducing the steam chest pressure below the lubricator pressure, establishing a live steam current through the oil pipe from the lubricator to the steam chest, will always tide an engine over this difficulty.

Siphoning.—Instances of siphoning from oil tanks, when feed valves were closed, steam and water valves open, and boiler allowed to cool off, are so rare that they may safely be said not to occur with the modern lubricator as constructed to-day. When cases of oil disappearance are met with, investigation will usually prove one or more mechanical defects present in the lubricator. The following are a few causes for loss of oil:

1. Pipe leading from condenser to bottom of oil tank being split, or bad joint where screwed into water passage.

2. Blow hole in casting, allowing oil to pass into steam channel or upper feed arms.

3. Imperfect joint made with the plug in opening, through which the oil supply pipe is sometimes inserted, has been followed by a loss of oil.

Mileage.—This is a feature that cannot be disposed of without many considerations of conditions and surroundings. It is an admitted fact that one man will use less oil on one engine than he could possibly get along with on another engine of the same class. It is largely, therefore, a matter of judgment of the engine man in charge how much oil is to be used or is required on that particular engine, without regard to the mileage made by some other engine under what

would almost seem similar conditions. The lubricator should be set to afford good and sufficient lubrication to valves and cylinders, and feeds should not be closed unless stops exceed ten minutes.

Instruction for the use of valve oil.—In one pint of valve oil there are, when fed through a lubricator in good repair, not less than 6,600 drops. A feed of five drops per minute will ordinarily be found sufficient for the largest engines and heaviest service; for smaller engines, or light service, a comparatively slower feed of oil will be found sufficient. A feed of one drop per minute is sufficient for an air pump.

At a feed of five drops per minute for each cylinder, and one drop per minute for air pump, ten hours' steady service can be obtained from one pint of valve oil.

Intelligent and economical results cannot be obtained unless engine men know the rate at which oil is being fed through the lubricators. If a small quantity of oil is put in a lubricator, time must be allowed for the condensation to fill the cup, and raise the oil to the top of the feed pipes before the feed valves are opened.

Immediately after the oil is put in the lubricator the steam and condenser valves should be opened; the steam valve should always be opened first and opened full, and should be shut last. By bearing this in mind, as before stated, most trouble with lubricators will disappear, water in feed glasses will remain clear, and there will be no loss of oil by siphoning.

The feed valves should be opened and set a few minutes before starting on the trip, and if the

lubricator is in good repair there will be little or no variation in the feed between using steam and when the throttle of the engine is shut.

Irregularity in feed of lubricators is usually due to enlarged opening in choke plugs. The holes in choke plugs should not exceed 1-32 of an inch.

Great care should be taken when filling the lubricator that no foreign substance be allowed to get into it. Owing to the smallness of the openings through which the oil passes, it does not take much to clog them.

If engine or other oil is mixed with valve oil, its fire test is reduced, and its value as a lubricant for valves and cylinders is gone.

Extravagant use of valve oil results in clogged-up exhaust pipes, and a consequent increase in coal consumption.

Working water or damp steam, or slipping an engine to get water out of cylinders, is considered bad practice, and has a bad influence on valve and cylinder lubrication.

While engine is standing it may be ascertained whether openings in choke plugs are too large or not by closing cylinder cocks, placing lever in center, blocking driving wheels, and opening throttle valve of engine, the open feed valves of lubricator. After determining by the watch the rate of speed per minute, close throttle valve and open cylinder cocks; if feed of lubricator increases, it can usually be charged to enlarged choke plug openings; if either or both equalizing steam pipes to lubricator are clogged, the result will be the same, but the latter condition is rarely found.

TABLE SHOWING PERFORMANCE OF LUBRICATORS WITH GOOD VALVE OIL

Capacity of Lubricators.	Total Number of Drops Contained In Lubricator.	Number of Drops for Each Cylinder per Minute	Hours Comsumed in Feeding-out 1 Lubricator.	Total Miles Run on a Basis of		Number of Miles Run to One Pint of Oil on a Basis of	
				Passenger, 30 Miles per Hour.	Freight, 18 Miles per Hour.	Passenger, 30 Miles per Hour.	Freight, 18 Miles per Hour.
2 Pints	13,200	5 Drops	22 Hours	660 Miles	396 Miles	330 Miles	198 Miles
3 Pints	19,800	5 Drops	33 Hours	990 Miles	595 Miles	330 Miles	198 Miles
Triple Feed, 3 Pints.	19,800	5 Drops, and 1 Drop for Air Pump.	30 Hours	900 Miles	540 Miles	300 Miles	180 Miles
5 Feed 5 Pints.	33,000	5 Drops ea. cyl. and ea. steam chest; 1 Drop Air Pump	26 Hours	780 Miles	468 Miles	156 Miles	94 Miles

Explanation of the Hydrostatic Principle of sight-feed lubricators.—It will be of advantage to those who would come to a complete understanding of the modern sight-feed lubricator to carefully note how simple is its working, as described by a well-known lubricator manufacturer.*

"A common double connecting hydrostatic sight-feed lubricator, if detached from all steam sources and set upon a table, its oil reservoir completely filled with oil and its condenser and sight-feed glasses filled with water, will feed perfectly when set to operate—the hydrostatic principle being then most perfectly illustrated, because there is an absolute equality of pressure (an atmospheric pressure of about 15 pounds per square inch) at the steam intake and oil outlet ends of the lubricator, in which case we have a liquid body suspended between two equal and, therefore, non-opposing forces, the oil being actuated or moved out of the oil-feed nipple by the heavier weight of water suspended over it.

"When the oil drop has left the nipple the hydrostatic feature has performed its function, the oil being floated out of the sight-feed glass by the difference between the specific gravity of the oil and the water in the glass. If we increase the pressure at the condenser end only, the lubricator will increase its feed, being actuated then not only by the weight of water, but also by this additional condenser pressure. On the other hand, if we increase the pressure at the oil delivery arm only, the feed of the lubricator will be retarded in a corresponding ratio, and, if the pressure

* F. W. Marvin.

is sufficiently increased, it will overcome the hydrostatic pressure and cause the lubricator to stop feeding altogether.

"Hence it is obvious that a perfect equality of pressure at the top of the condenser and at the oil delivery pipes is absolutely necessary to a common hydrostatic, or the feed will not be uniform.

"It is for this reason that when applied to a stationary engine its condensing tube and oil delivery arms are both connected to a steam pipe on the boiler side of the engine throttle in order that closing the throttle shall not affect the steam pressure at either end of the lubricator. Thus such a lubricator requires no equalizing tubes or chokes, and feeds its oil perfectly and steadily, regardless of pressure or whether the throttle is open or closed. Change the connections of this same lubricator, leaving the condenser tube still connected on the boiler side of the engine throttle, but remove the oil delivery connection to the cylinder side of the throttle (that is, straddle the throttle), and note the results: As long as the throttle is wide open the lubricator continues to feed hydrostatically; but the moment we close the throttle we have removed all the pressure from the oil discharge arms and left the pressure on the condenser, and immediately the lubricator feeds with the weight of water plus the boiler pressure, thus racing and emptying itself rapidly. Hence it will be seen that straddling the throttle produces conditions analogous to those of a locomotive, and consequently the necessity of locomotive lubricator requirements, as follows:

"(1) An equalizing tube is added, which is simply a by-pass around the throttle to replace to the oil dis-

charge arm of the lubricator the pressure that was lost when the throttle was closed; and still we have not bettered conditions, because the oil discharge pipe is so large that it permits an outflow of steam as fast as the equalizing tube can supply it. Therefore it is necessary to also add a choke between the equalizing tube and the oil outlet in order to maintain boiler pressure within the lubricator feed arm at all times."

While most locomotive lubricators have the choke plugs located within the lubricator, others place them at or near the steam chest in order to avoid a flow of steam *up* the oil supply pipes.

DETROIT TRIPLE-FEED LOCOMOTIVE LUBRICATOR WITH AUTOMATIC STEAM CHEST VALVES.

The 1900 pattern of the Detroit locomotive lubricator is fully illustrated and the various valves described in what follows:

The automatic steam chest valves furnished with this lubricator are to be connected directly above the steam chests, and are sent out blank so they can be threaded to fit the plugs already in the steam chests. It is claimed they are so constructed that a continuous, uninterrupted feed of oil is maintained to the steam chests and cylinders under all conditions of throttle position, *and there is no danger of their becoming inoperative through the lodging of dirt or sediment in restricted passages.*

The use of the old style auxiliary oilers is necessarily accompanied by a good deal of spilling and general waste of oil, and in order to avoid this, this

lubricator is equipped with by-pass valves for auxiliary oiling. The by-pass valve is shown in section on the right-hand side of plan view, Fig. 3. These by-pass valves are intended to be used only when, on account of a broken glass or other cause, the oil cannot be fed through the sight-feed glass. At all other times these by-pass valves should be kept closed tightly on their seats. The stems of the by-pass valves are graded to feed at exactly the same rate as the regular regulating feed valves *EE*, so that an eighth turn opening or a quarter turn opening of the by-pass valve will allow the same quantity of oil to be fed as an eighth turn opening or a quarter turn opening of the regulating feed valve *E*.

Each sight-feed glass is provided with an automatic safety valve, a sectional view of which is shown in Fig. 2, and on a larger scale in Fig. 5. Each drop of oil has to pass through this safety valve, and in doing so it pushes the check, No. 17b, open. After the drop passes out this check seats again until the next drop appears. Should the glass be broken from any cause, the check No. 17b remains tightly closed and prevents the escape of any steam or oil to injure those in the cab. This safety valve also protects the glass from the steam passing through the equalizing pipes. Where the steam has free access to the sight-feed glasses, the upper parts of these glasses soon become worn thin and break, being cut away by the eddying motion of the steam as by a sand blast. Hence an advantage is claimed for this design.

This lubricator has only two external equalizing tubes, one for each steam cylinder. The equalizing tube for the air pump feed is located inside the

condenser, and is shown in Fig. 1, part No. 11. The gauge glass is provided with an automatic check valve in both upper and lower gauge arms, so that in case it should be broken no oil or water can escape. One of the checks is shown in Fig. 3, part No. 27c.

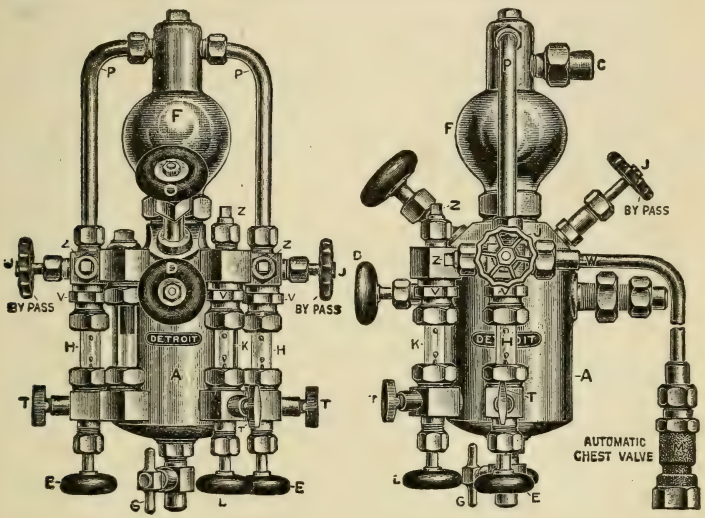


FIG. A.
(Front View.)

FIG. B.
(Side View.)

Detroit Triple Feed Locomotive Lubricator.

F–Condenser.
A—Oil Reservoir.
O—Filler Plug.
G—Drain Plug.
D—Water Feed Valve.
EE—Feed Regulating Valves to Right and Left Hand Cylinders.
L—Feed Regulating Valve to Air Pump.
ZZZ—Automatic Safety Valves.
JJJ—By-Pass Valves to Right and Left Hand Cylinders and to Air Pump.
WW—Coupling to Right and Left Hand Cylinders.
R—Coupling to Air Pump.

Directions for application.—1st. Secure the Lubricator to boiler-head or to top of boiler by strong bracket.

2nd. Connect Lubricator at coupling *C* to boiler

space, using copper pipe of 13-16 outside diameter or its equivalent, and a $\frac{3}{4}$ inch valve at boilers.

3rd. Connect with tallow pipes at couplings *WW*, and with air pump at coupling *R*.

4th. Automatic chest plugs furnished with the Lubricator can be threaded to fit plugs already on steam chests.

5th. The fitting to which our steam chest valve is attached should be bored to $\frac{1}{4}$ inch hole.

Directions for operating.—When the lubricator is first applied, blow out thoroughly, then close all the valves.

To fill.—Remove filler plug *O*, and fill the reservoir *full* with clean, strained oil.

To start lubricator.—1st. Open boiler valve gradually until wide open, and allow sufficient time for condenser and sight-feed glasses to fill with water. Keep wide open while lubricator is in operation.

2nd. Open water-feed valve *D*.

3rd. Regulate the flow of oil to right and left hand cylinders by valves *EE*, and to air pump by valve *L*.

To refill.—Always close valves *EE* and *L* in advance of valve D. Open drain plug *G*, then filler plug *O*. Refill and proceed to operate as before.

It is important that valves *ZZZ* contain automatic safety valves, and should be kept closed when the lubricator is in operation.

To clean glasses.—Open valve *T*, unseat safety valve *Z*, and when glasses are cleaned close valve *T*, and after the glasses have filled with water screw valve *Z* tight to its seat and leave in that position.

No hand oiler is attached to this lubricator, and none is required. The by-pass valves *JJJ* control

this feature, and are to be operated as follows: Always keep closed unless the sight feed glass becomes broken. In that event, close the feed regulating valve under the broken glass and use the by-pass valve as a hand

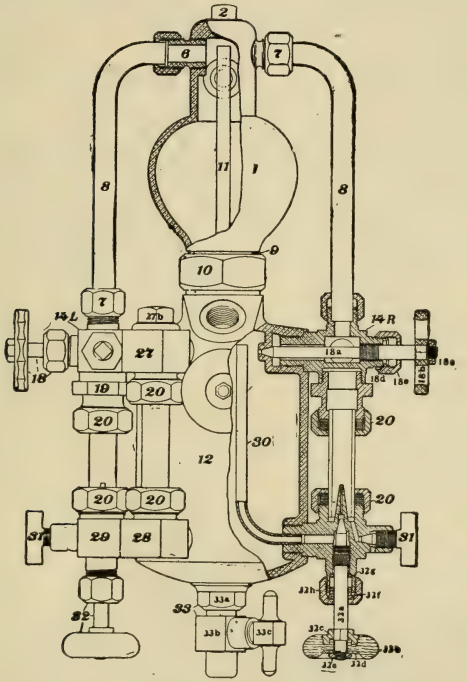


FIG. 1.
Detroit Triple Feed Locomotive Lubricator.
(Front Elevation.)

oiler. Regulate the feed identically the same as with a regulating valve, remembering always that an opening corresponding with that of the feed-regulating valve will give an equal quantity of oil through

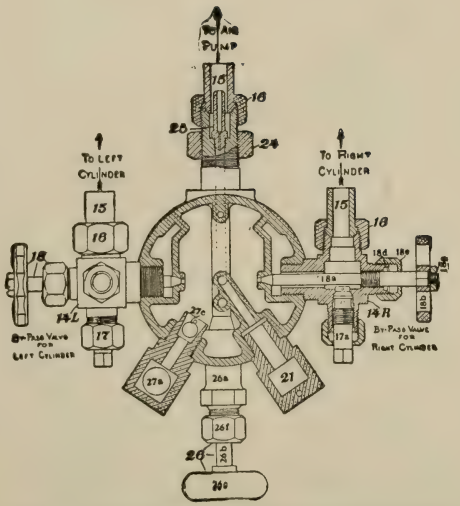


FIG. 3. Detroit Triple Feed Locomotive Lubricator.
(Plan View.)
Showing cross-section view, as though lubricator was cut open horizontally on the line of upper sight feed arms.

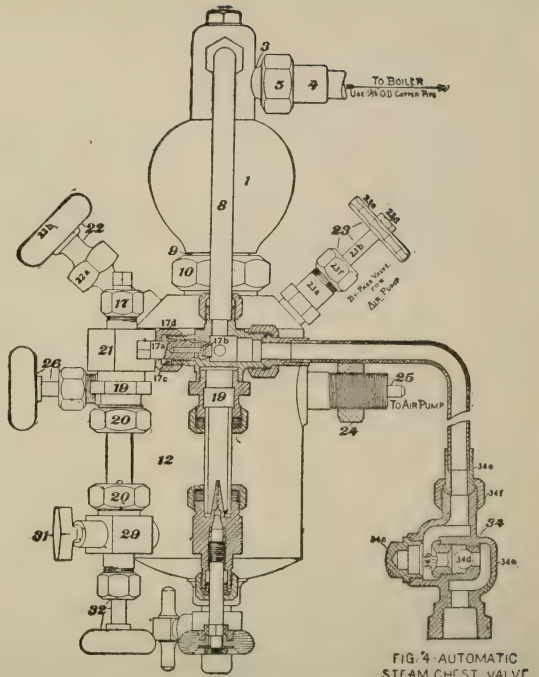


FIG. 4. AUTOMATIC STEAM CHEST VALVE

FIG. 2. Detroit Triple Feed Locomotive Lubricator.
(Side Elevation.)

the by-pass, guarding against too great an opening of the by-pass valve and consequent waste of oil. In no event is it necessary to close the locomotive throttle or any valve of the lubricator, excepting the regulating valve under the broken sight-feed glass, to use the by-pass valve as an auxiliary oiler.

LIST OF PARTS FOR DETROIT TRIPLE LOCOMOTIVE LUBRICATOR.

Figs. 1, 2 and 3.

No.

1. Condenser.
2. Condenser Plug.
3. Boiler Nipple.
4. Boiler Nipple Tail Pipe.
5. Boiler Nipple Tail Pipe Nut.
6. Equalizing Tube Nipple.
7. Equalizing Tube Nipple Nut.
8. Equalizing Tube.
9. Condenser Tail Pipe.
10. Condenser Tail Pipe Nut.
11. Air Brake Equalizing Tube.
12. Oil Reservoir.
13. Water Tube Complete.
14r. Upper Feed Arm, Right.
14l. Upper Feed Arm, Left.
15. Tail Pipe.
16. Tail Pipe Nut.
17. Automatic Safety Valve, complete.
    - 17a. Stem.
    - 17b. Check.
    - 17c. Bush Ring.
    - 17d. Packing Nut.
18. By-Pass Valve, R. or L. Cylinder, Complete.
    - 18a. Stem.
    - 18b. Stem Handle.
    - 18c. Stem Handle Nut.
    - 18d. Stem Bush Ring.
    - 18e. Stem Packing Nut.
19. Extension Sleeve.
20. Packing Nut.
21. Upper Air Brake Arm.
22. Filler Plug, Complete.
    - 22a. Filler Plug.
    - 22b. Filler Plug Handle.
    - 22c. Filler Plug Handle Plate.
    - 22d. Filler Plug H'dle Washer.
    - 22e. Filler Plug H'dle Washer Nut.
    - 22f Filler Plug Copper Seat.
23. By-Pass Valve for Air Brake, Complete.
    - 23a. Centre Piece.
    - 23b. Stem.
    - 23c. Handle.
    - 23d. Handle Nut.
    - 23e. Gland.
    - 23f. Packing Nut.
24. Support-Arm Nut.
25. Air-Brake Nozzle.
26. Water Valve, Complete.
    - 26a. Center Piece.
    - 26b. Stem.
    - 26c. Handle.
    - 26d. Handle Nut.
    - 26e. Gland.
    - 26f Packing Nut.
    - 26g. Handle Washer.
27. Upper Gauge Arm, Complete.
    - 27a. Upper Gauge Arm.
    - 27b. Upper Gauge Arm Plug.
    - 27c. Upper Gauge Arm Ball Check.
28. Lower Gauge Arm, complete.
    - 28a. Lower Gauge Arm.
    - 28b. Lower Gauge Arm Ball Check.
29. Lower Feed Arm.
30. Oil Tube.
31. Vent Stem.
32. Regulating Valve, Complete.
    - 32a. Stem.
    - 32b. Handle.

32c. Handle Plate.

- 32d. Handle Washer.
- 32e. Handle Washer Nut.
- 32f. Gland.
- 32g. Bush Ring.
- 32h. Packing Nut.

33. Drain Valve, Complete.
    - 33a. Drain Valve Seat.
    - 33b. Drain Valve Body.
    - 33c. Drain Valve Stem.
34. Automatic Steam Chest Valve, Complete.
    - 34a. Body.
    - 34b. Seat.
    - 34c. Plug.
    - 34d. Ball Check.
    - 34e. Tail Pipe.
    - 34f. Tail Pipe Nut.

To insert the sight-feed glass.—Place the gland nuts and the extension sleeve *V* around the glass in the order shown. Then pass the lower end of the glass over the point of the nozzle, as indicated in the left-

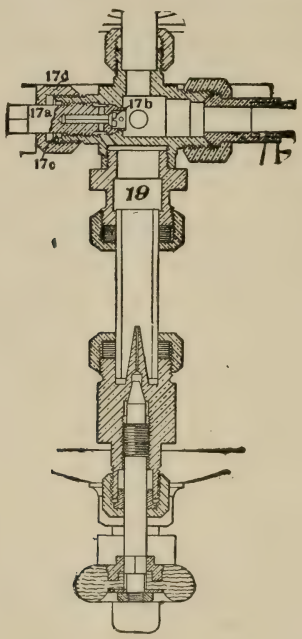


FIG. 5.
Detroit Triple Feed Locomotive Lubricator.
Sectional view of feed—snowing automatic safety valves above the glasses.

hand cut, and place the glass in position. Then screw the sleeve *V* in place, and tighten up the gland nuts.

To remove the glass, first unscrew the gland nuts and push the upper one down until it touches the

lower one. Then unscrew the sleeve *V*, pushing it down slightly on the glass also, and the whole will pass out easily.

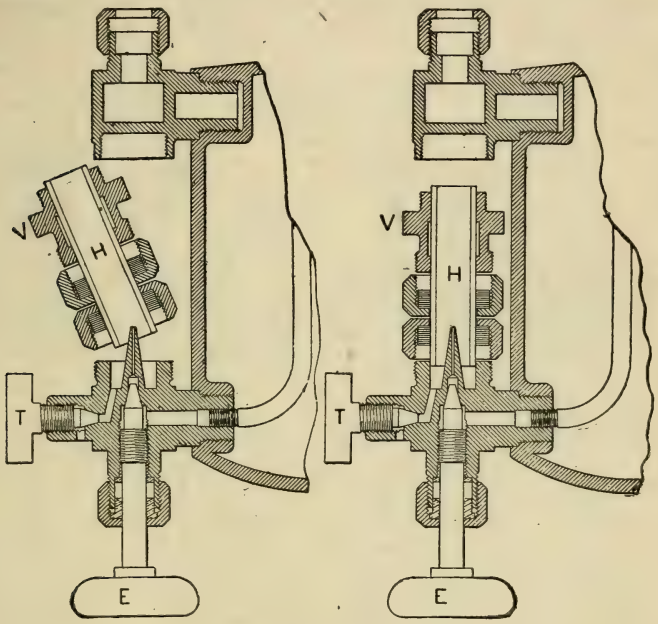


FIG. 6.

Detroit Triple Feed Locomotive Lubricator.
Showing manner of inserting and removing sight-feed glass.

THE DETROIT TRIPLE-FEED LOCOMOTIVE LUBRICATOR WITH TIPPETT ATTACHMENT.

The tippett attachment has been designed to insure the regular delivery of the oil to the wearing parts by overcoming the back pressure from the steam chests. It consists of a pipe leading to the dry-pipe within the

boiler and communicating with the two tallow pipes, as shown in Fig. As soon as the throttle is opened, an extra current of steam from the dry pipe is admitted into the tallow pipes. This, it is claimed,

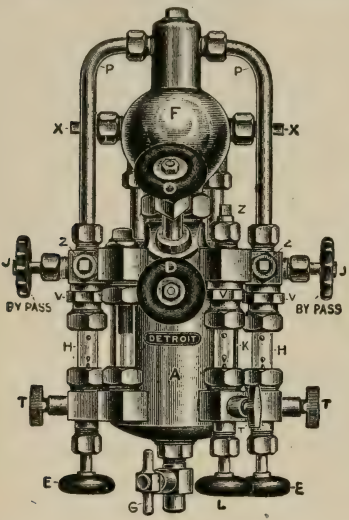


FIG. A.
Detroit Triple Feed Locomotive Lubricator with Tippett Attachment. (Front View.)

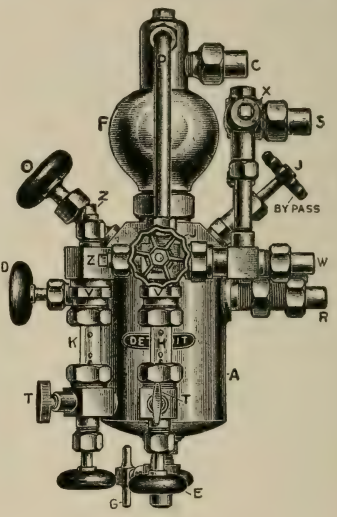


FIG. B.
Detroit Triple Feed Locomotive Lubricator with Tippett Attachment. (Side View.)

C—Boiler Connection.
F—Condenser.
A—Oil Reservoir.
O—Filler Plug.
G—Drain Plug.
D—Water Feed Valve.
EE—Feed Regulating Valves to Right and Left Hand Cylinders.
L—Feed Regulating Valve to Air Pump.

ZZZ—Automatic Safety Valves.
JJJ—By-Pass Valves to Right and Left Hand Cylinders and to Air Pump.
WW—Coupling to Right and Left Hand Cylinders.
R—Coupling to Air Pump.
S—Dry-Pipe Connection.
XX—Valves in Yoke of Tippett Attachment.

overcomes the back pressure from the steam chests and creates a circulation of steam in the tallow pipes towards the cylinders. Hence, as soon as the drop of oil rises through the sight-feed glass, it is carried at

once to the wearing parts, as intended, and a steady delivery of the oil to the cylinders is assured under all conditions of throttle position. In connecting the tippett attachment, a copper pipe 13-16 inch outside

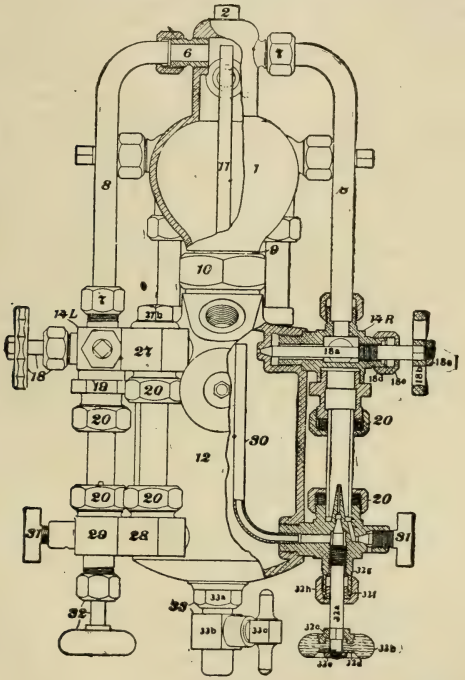


FIG. 1.

Detroit Triple Feed Locomotive Lubricator with Tippett Attachment.
(Front Elevation.)

diameter should be used, as shown in cut, and it is recommended that this pipe be brazed to the swivel *N* instead of being screwed into same. The pipe used for connecting the condenser to the boiler should be $\frac{5}{8}$-inch outside diameter copper pipe.

Directions for application.—1st. Secure the Lubricator to boiler-head or to top of boiler by strong bracket.

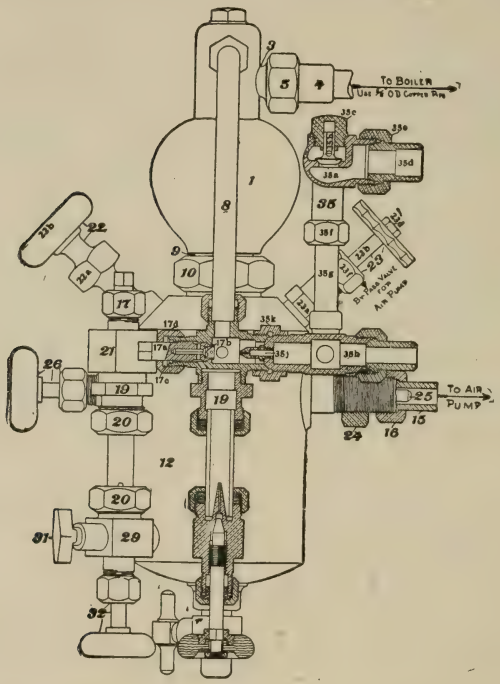


Fig. 2.

Detroit Triple Feed Locomotive Lubricator with Tippett Attachment.
(Side Elevation.)

2nd. Connect Lubricator at coupling *C* to boiler space, using copper pipe of $\frac{5}{8}$ outside diameter or its equivalent, and a $\frac{1}{2}$ inch valve at boiler.

3rd. Connect coupling *S* with Dry Pipe as shown

in cut on opposite side using copper pipe 13-16 in. (outside) diameter.

4th. Connect with tallow pipes at couplings *WW* and with air pump at coupling *R*.

5th. Reduce the opening at steam chest plugs to 3-16 in.

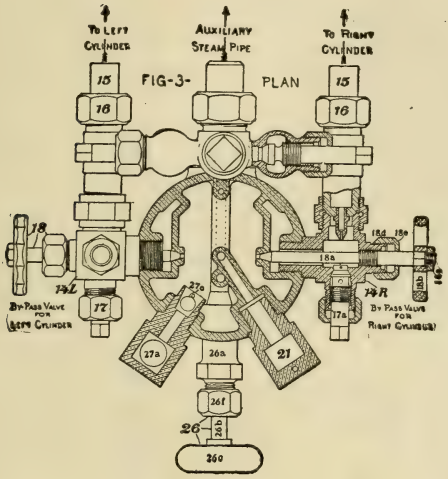


FIG. 3.

Detroit Triple Feed Locomotive Lubricator with Tippett Attachment. (Plan View.)

The above cut shows cross section view as if Lubricator were cut open horizontally on the level of the upper sight feed arms.

The steam chest oil pipe plug should be of the pattern shown in Fig. 5, having a hole 3-16 inch in diameter at the bottom.

When lubricator is applied to simple engine, open full both valves *XX*, and leave in that position.

When application is made to Cross Compound

Engines, open full valve X on side to high-pressure steam chest, and close tight valve X on side to low-pressure steam chest, and leave in that position.

LIST OF PARTS FOR DETROIT LOCOMOTIVE LUBRICATOR WITH TIPPETT ATTACHMENT.

Figs. 1, 2 and 3.

No.

1. Condenser.
2. Condenser Plug.
3. Boiler Nipple.
4. Boiler Nipple Tail Pipe.
5. Boiler Nipple Tail Pipe Nut.
6. Equalizing Tube Nipple.
7. Equalizing Tube Nipple Nut.
8. Equalizing Tube.
9. Condenser Tail Pipe.
10. Condenser Tail Pipe Nut.
11. Air Brake Equalizing Tube.
12. Oil Reservoir.
13. Water Tube Complete.
14r. Upper Feed Arm, Right.
14l. Upper Feed Arm, Left.
15. Tail Pipe.
16. Tail Pipe Nut.
17. Automatic Safety Valve, Complete:
    - 17a. Stem.
    - 17b. Check.
    - 17c. Bush Ring.
    - 17d. Packing Nut.
18. By-Pass Valve, R. or L. Cylinder, Complete.
    - 18a. Stem.
    - 18b. Stem Handle.
    - 18c. Stem Handle Nut.
    - 18d. Stem Bush Ring.
    - 18e. Stem Packing Nut.
19. Extension Sleeve.
20. Packing Nut.
21. Upper Air Brake Arm.
22. Filler Plug, Complete.
    - 22a. Filler Plug.
    - 22b. Filler Plug Handle.
    - 22c. Filler Plug Handle Plate.
    - 22d. Filler Plug H'dle Washer.
    - 22e. Filler Plug H'dle Washer Nut.
    - 22f. Filler Plug Copper Seat.
23. By-Pass Valve for Air Brake, Complete.
    - 23a. Centre Piece.
    - 23b. Stem.
    - 23c. Handle.
    - 23d. Handle Nut.
    - 23e. Gland.
    - 23f. Packing Nut.
24. Support Arm Nut.
25. Air-Brake Nozzle.
26. Water Valve, Complete.
    - 26a. Center Piece.
    - 26b. Stem.
    - 26c. Handle.
    - 26d. Handle Nut.
    - 26e. Gland.
    - 26f Packing Nut
    - 26g. Handle Washer.
27. Upper Gauge Arm, Complete.
    - 27a. Upper Gauge Arm.
    - 27b. Upper Gauge Arm Plug.
    - 27c. Upper Gauge Arm Ball Check.
28. Lower Gauge Arm, Complete.
    - 28a. Lower Gauge Arm.
    - 28b. Lower Gauge Arm Ball Check.
29. Lower Feed Arm.
30. Oil Tube.
31. Vent Stem.
32. Regulating Valve, Complete.
    - 32a. Stem.
    - 32b. Handle.
    - 32c. Handle Plate.
    - 32d. Handle Washer.
    - 32e. Handle Washer Nut.
    - 32f. Gland.
    - 32g. Bush Ring.
    - 32h. Packing Nut.
33. Drain Valve, Complete.
    - 33a. Drain Valve Seat.
    - 33b. Drain Valve Body.
    - 33c. Drain Valve Stem.
35. Tippett Yoke, Complete.
    - 35a. Tippett Yoke.
    - 35b. Tippett Yoke Check.
    - 35c. Tippett Yoke Plug.
    - 35d. Tippett Yoke Tail Pipe.
    - 35e. Tippett Yoke Tail Pipe Nut.
    - 35f. Tippett Yoke Con'g Nut.
    - 35g. Tippett Yoke Con'g Tail Pipe.
    - 35h. Tippett Arm, Right.
    - 35i. Tippett Arm, Left.
    - 35j. Tippett Arm, Nozzle.
    - 35k. Tippett Arm, R. and L. Connecting Nut.
36. Dry-Pipe Fitting, Complete.
    - 36a. Dry-Pipe Fitting.
    - 36b. Dry-Pipe Fit'g Tail Pipe.
    - 36c. Dry-Pipe Fit'g Tail Pipe Nut.
37. Expansion Joint.
    - 37a. Expansion Joint.
    - 37b. Expansion Joint Nut.
    - 37c. Expansion Joint Gland.

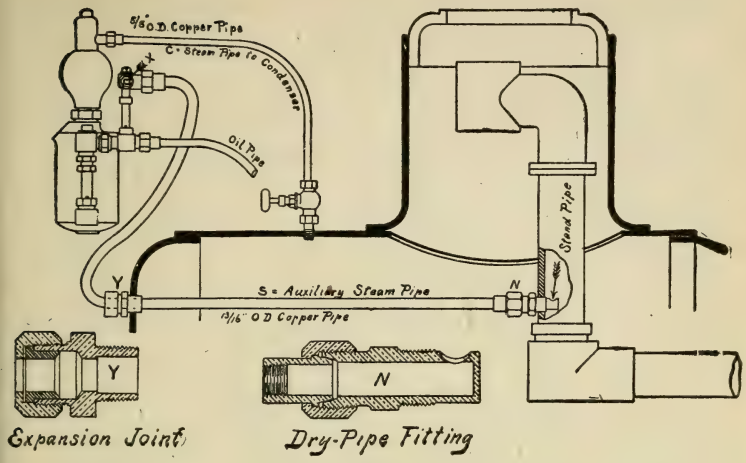


FIG. 4.

Detroit Triple Feed Locomotive Lubricator with Tippett Attachment. Showing method of connecting Tippett Attachment to Locomotive.

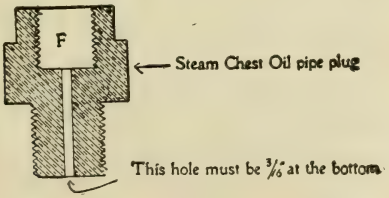


FIG. 5.

Steam Chest Oil Pipe Plug.

THE DETROIT LOCOMOTIVE LUBRICATOR NO. 21 BULL'S EYE PATTERN.

The Detroit No. 21 (Figs. 6, 7, 8, 9, 10 and 11) is claimed by its makers to be superior to other lubricators in the following respects; it has a sight-feed glass that will not break thus obviating danger of injury to enginemen and delays resulting from burst lubricator glasses. The glass used and the method of packing are indicatd in Fig. 7. It is also claimed for it that it occupies one-fourth less space in the cab and has fewer parts and metal joints.

DIRECTIONS FOR OPERATING.

Steam for lubricator should be taken from turret if large enough, or from dome through an independent dry pipe of one-inch iron pipe size or its equivalent.

When the lubricator is first applied, blow out thoroughly, then close all the valves.

To FILL.—Remove Filler Plug O and fill the reservoir with clean, strained oil.

NOTE.—If there is not sufficient oil to do so, always use water to make up the required quantity. This will enable the feeds to start promptly.

STEAM VALVE.—The regular boiler valve should be left wide open, and the steam valve B at top of condenser must also be kept wide open while the locomotive is in service.

To START LUBRICATOR.—1st. Be sure that the regular boiler valve is open. Then open steam valve B at top of condenser wide and keep wide open while lubricator is in operation. Allow sufficient time for condenser and sight feed glasses to fill with water. 2d. Open water valve D. 3d. Regulate flow of oil to right and left cylinders by valves EE and to air pump by valve L.

To OPERATE AUXILIARY OILERS.—See that valve H is closed. Then open valve X and fill body of oiler. Close X after filling, and open valve H.

To REFILL.—Always close valves EE and L in advance of valve D. Open drain plug G, then filler plug O. Refill and proceed as before.

If at any time it becomes necessary to fill the lubricator with cold oil and the engine will remain out of service for some hours, do not fail to turn on slight steam pressure

NO. 21.

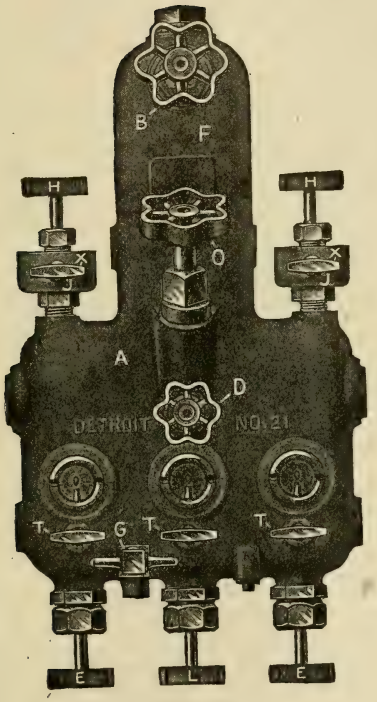


Fig. 6.

from the boiler and open valve D in order to prevent excessive pressure from expansion of the oil.

Blowing Out.—Blow out lubricator once a week or oftener if necessary.

Getting New or Rebuilt Locomotive Ready for Service.—In getting a new or rebuilt locomotive ready for service, disconnect oil pipes at steam chest, and blow out thoroughly both oil pipes and automatic steam chest valves; also disconnect coupling to air pump and see that choke is free. Do this several times while getting the engine ready for service.

Do not screw up too tightly the feed glass follower (See Fig. 12), as this will only serve to injure the packing. There is no danger of leakage at this point, as the glass and packing are so designed that the greater pressure from the inside the better the joint.

Filling.—If there is not sufficient oil to fill the lubricator, always use water to make up the required quantity. This will enable the feeds to start promptly.

If at any time it becomes necessary to fill the lubricator with cold oil, and the engine will remain out of service for some hours, do not fail to turn on slight steam pressure from the boiler and open valve D in order to prevent any excessive pressure from expansion of the oil.

Note A.—The steam valve B (See arrow 1 on Fig. 9) must be opened wide when the locomotive is in service, to allow condensation to enter the condenser; otherwise condensation will be diverted to equalizing tubes. The feeds will gradually slow down as the water of condensation decreases.

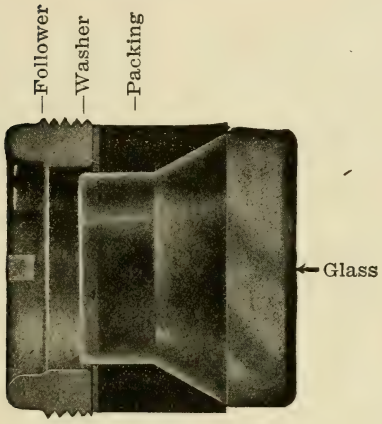
Note B.—When getting a new or rebuilt engine ready for service, or when using soda ash boiler compounds, or when running in bad water districts, impurities will be carried over into the condenser and will gradually accumulate at base of water valve (See arrow 2 on Fig. 9) until the water is completely shut off. Sometimes these impurities lodge above the water check (See arrow 3, Fig. 11.)

While this is taking place the feeds are affected the same as described in Note A, and when this passage is finally closed by the sediment, the feeds will cease altogether.

How to Rectify While Locomotive is in Service.—Close all feeds and water valve; open drain cock 2105 and allow about one-half pint of water to drain off; close drain cock and open water valve quickly. The condenser pressure will then force this sediment into bottom of lubricator, where it can be blown out in the usual manner, when the lubricator is empty.

Note C.—If the lubricator is reported syphoning, look for the trouble at water check 2238. (See arrow 3 on Fig. 11.)

GLASS AND METHOD OF PACKING.



FULL SIZE.

Direction of pressure indicated by arrow.
The higher the pressure the better the joint.

Fig. 7.

Cause, scale or borings prevent ball check from seating, or the check may have been lost by removing plug 2239.

Do not screw up too tightly the feed glass follower, (See Fig. 12) as this will only serve to injure the packing. There is no danger of leakage at this point as the glass and packing are so designed that the greater the pressure the better the joint.

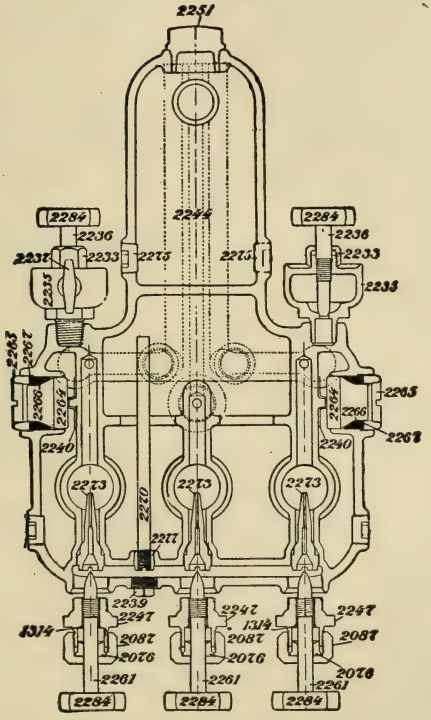
Small Drop of Oil.—The cause of a small drop of oil or the variation of size of drop during a trip. In alkali, salt water or oil well regions through which railroads pass, the water supply becomes impregnated with saline matter. The saline matter is carried over in the lubricator mechanically by the steam, so that the water in the sight feed glasses contains considerable of it, and the amount increases as the locomotive proceeds on the trip until it crystalizes around the feed cones, thus gradually dim'nishing the size of the opening for the drop. Should the engineer undertake to force the feed it will result in the oil flowing in a very slender stream, scarcely perceptible. If this condition is not corrected, the salt crystals will completely close the feed cone orifice. Salt water is more buoyant than fresh water, and for tnat reason it forces the drop of oil off the feed cone in less time. The result is a small drop of oil and more drops per minute.

How to Rectify.—Close all feed stems; open all sight feed drain stems and blow out thoroughly. The action of the steam on feed cones will dissolve the salt crystals. Allow reasonable time for condensation; start the feeds, and the drop of oil will be normal.

Air Bound.—This condition is almost invariably brought about whenever it becomes necessary to fill a lubricator on the road. The temperature of a lubricator at such times is very nearly that of the steam pressure temperature. Sometimes the water feed valve or feed stem seat may leak, and in order to fill the lubricator in this heated condition it is found necessary to shut off all steam pressure to the lubricator, including the air pump, and owing to the high temperature of the condenser the water flashes into steam, practically emptying the condenser and feed glasses of all water. The oil reservoir being very hot, the oil expands rapidly, and the filler plug is usually put in before the reservoir is full. The steam and water pressures are hurriedly turned on and the feeds are opened before sufficient time has elapsed for condensation to accumulate. The feeds will not respond under such conditions because the positive and negative pressures have equalized and the lubricator is said to be air bound.

How to Overcome.—Open all feeds and any one of the sight feed drain stems. This will allow the water in the oil tubes and the air or gas occupying the highest space in

NO. 21.



FRONT VIEW.

Fig. 8.

the oil reservoir to escape to atmosphere. The oil will quickly follow. Then shut this feed and vent stem until the condensation again fills the sight feed chamber.

Getting New or Rebuilt Locomotive Ready for Service.—In getting a new or rebuilt locomotive ready for service, disconnect oil pipes at steam chest, and blow out thoroughly both oil pipes and automatic steam chest valves, also disconnect coupling to air pump and see that choke is free. Do this several times while getting the locomotive ready for service.

Irregular Feeding or Racing.—If a lubricator feeds irregularly, look for the trouble at the automatic steam chest valves or in such chokes as are located at the lubricator end of tallow pipes. When the opening through any of these chokes is enlarged above the standard, the feed will "race" or be more rapid.

Care of Lubricator.—With high steam pressure there is a tendency, even with good valve oil, to deposit a gummy substance resembling vaseline around the feed stems and cones. This substance can be removed and the glasses cleaned and filled by the following method: After the oil is all fed from the lubricator, leave the pressure turned on and close all feeds but one; open vent stem to this one, which will allow the condensation to circulate, and thoroughly cleanse the feed stem, cone and glass. Close vent stem. The glass immediately fills with condensation from lubricator. Close feed stem. Repeat same operation with other feeds. Close the water feed valve, blow out body and fill with oil in the usual manner.

Traps in Oil Pipe.—It is of the greatest importance that there be no traps in the oil pipes between the lubricator and steam chest, otherwise the oil will trap. The time required to fill a trap depends largely upon the diameter of pipe, and form or length of a trap as well as the rate of feed per minute. It must be remembered that the oil pipes are filled with steam at boiler pressure and temperature; that circulation or draw of steam is equal to the diameter of the choke at the steam chest or 5-64 inches.

It must be evident that the practice of locating the oil pipes on top of the boiler head of the Belpaire or whale type of boilers, or running the oil pipes on a level the full length on the side of the firebox before the oil pipes incline towards the steam chest will cause a trap when the locomotive is ascending grades; in other words, the locomotive and the grade form a trap unless the oil pipes have a gradual descent from lubricator to steam chest.

Round House Repairs.—If a lubricator is reported as not feeding, look for the trouble as described in Note A, or in oil tube No. 2270. Should this oil tube become loose in

NO. 21.

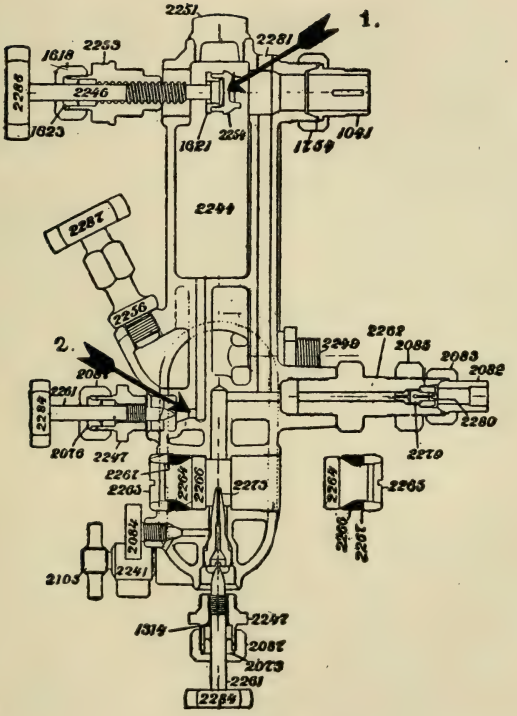

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Fig. 9.

bushing No. 2277, or bushing loose in body, water would find its way into oil feed chamber. It is understood that water occupies the space in both the oil tube and chamber when the lubricator has fed empty or after condensation has been drawn from lubricator body in the usual manner.

FEEDING AROUND THE METAL BETWEEN THE GLASSES.—If reported as feeding around metal between the glasses, there are only two causes.

1st. The feed cone No. 2273 is loose or has a faulty seat. The oil will flow upward around the clearance of the thread, passes feed cone seat, adheres to the metal and passes around and out of sight feed chamber by capillary action.

2d. Sediment is allowed to gather around feed cones to the extent that the oil adheres to it, creeps down and passes out of sight feed chamber for the same reason as in the case of a loose feed cone, viz., capillary action.

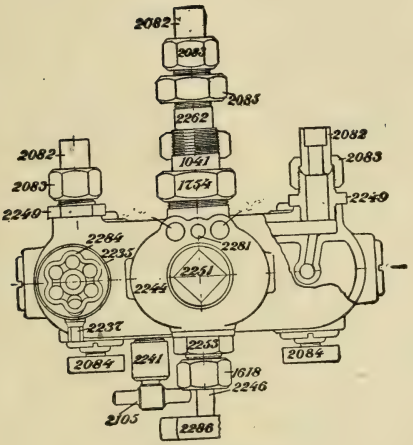
In the first cause, tighten feed cone No. 2273. The second cause is visible. Open vent 2084 and thoroughly blow out sight feed chamber. This will remove the sediment. Should the engineer not be an observing man, he will report the lubricator as feeding out several times on the road or that feeds stop or feed irregularly.

SAND HOLES.—This trouble is the most annoying and difficult to locate, for the reason that systematic methods or tests are seldom employed by the roundhouse repair men to locate the defects. If a lubricator is repeatedly reported as emptying itself on the road and no loose feed cones or sediment in sight feed chamber as previously described, are in evidence, apply the following test:

TEST NO. 1.

Disconnect all oil pipes at lubricator while it is in position on the locomotive. Have two cap nuts made for this purpose with 1-16 holes drilled in for chokes (the air pump tail pipe has a choke), or take two tail nuts No. 2083, using a copper gasket with a 1-16 hole. Screw these nuts (which are temporary chokes) on tail pipes center pieces No. 2249. The lubricator is now ready for the oil test which will determine in a few minutes whether there is a sand hole in any of the passages above the sight feed chambers or not. Fill the lubricator with oil, turn on full steam pressure, open water valve, but under no circumstances should the feed be opened until after oil test has been made. Hold a piece of white paper in the three jets of steam at repeated intervals from time to time. If there is no indication of oil in the steam, the lubricator has no sand hole, but if there is oil coming from any one, or all the three jets of steam, the lubricator has a sand hole and should be

NO. 21.



TOP VIEW.

Fig. 10.

taken out of service at once. An oil test of ten minutes is ample time to determine the condition of a lubricator.

This same test can and should be made after a lubricator has been repaired if the repair room is equipped with a testing rack and steam pressures; in fact, all repaired lubricators should be given a thorough test before they are put in service, as by such systematic methods delays and failures are eliminated when the lubricator is put in service.

TEST NO. 2, ROUNDHOUSE OR REPAIR ROOM.

If the engine is dead or the lubricator has been removed from an engine for repairs, apply tne following test: First remove all oil from body of lubricator; fill it with water; cut off a filler plug above the square; bore out to ¼ inch; tap out for ¼ inch gas pipe and introduce water, air or hydraulic pressure through this filler plug. If there is a sand hole, faulty feed cone seat, leaky water valve or feed stem, the defect will be quickly located by the blow or leakage.

After the defects have been remedied, the lubricator should be given a second test in order to determine if the work has been done thoroughly.

CAUTION—Do not overlook the automatic steam chest choke (or air pump feed choke), as it is of vital importance that these valves receive careful inspection both in the roundhouse or repair room.

If the lubricator feeds irregularly, such as slow when the engine is working at full capacity, fast or races when the throttle is closed, while the engine is drifting or at rest, look for the trouble at the automatic steam chest plugs. The lower ends of the 5-64-inch valves will be found worn, and should be reversed or renewed with standard ones when they have become cut away by the steam to 7-64-inch. This latter opening will unbalance the lubricator feeds not less than three drops per minute. It will thus be seen that it is of the greatest importance that more than ordinary care and attention be given the 5-64-inch chokes at the steam chest. A word of caution should be added in connection with the above; That the next important place to look for trouble is in the lubricator in the water passage between condenser and bottom of lubricator. In bad water districts the passage between the condenser and base of water valve will gradually lime up until the water pressure is cut off as completely as when the water valve is closed. (See notes B and C.)

SHOP REPAIRS.

When a lubricator is taken out of service and is in a filthy condition so far as outside appearance is concerned, it should be put in a vat of hot concentrated lye or potash without removing any of the parts. The lye

will not injure the glasses or gaskets, and none should be removed afterward except such glasses or gaskets as indicate failure. After a lubricator is taken from the lye vat, give it a thorough cleaning with water inside and out; next renew glasses and gaskets if necessary; then apply test No. 2 or No. 1, or both. Grind in water valve; blow out water passage, face up drain stem No. 2105. The filler plug, water valve and drain stem 2105 get the most abuse; therefore require careful repair. Do not remove feed cones unless the hydraulic test shows them to be faulty. The oil tube very rarely requires any attention unless the engineer reports that the drops of oil show foam, water or air bubbles; then it is evident that water is getting into the feed chamber either through a sand hole, loose oil tube, bush or cracked tube when it is screwed into bush. A sand hole into the oil feed chamber can be located by removing oil tube and bush (also remove all feed centers), screwing in a blank and applying the air or hydraulic pressure.

The majority of lubricator troubles can be corrected by a thorough blowing out, and by looking after the steam chest chokes.

TEST NO. 3.—ENGINEER ROAD.

Should the engineer have reason to believe that the oil is escaping through a sand hole to either of the steam chests or air pumps, he can determine to an absolute certainty the condition of a lubricator by the following method: The lubricator should not be less than two-thirds full of oil; the full steam and water pressure turned on as in service; open all vent stems No. 2084 to sight feed glass chamber and allow all water to escape and steam to blow through all the vents for about a minute; close any two vents; take scoop shovel, wipe it clean, hold it under the jet of steam coming from vent. If there is a sand hole through any one of the oil outlet passages, the steam will carry such oil downward and blow it on the scoop, when it will radiate or crawl in all directions from a common center. Repeat the same test on the other vents. It is needless to say if there is no oil deposited on the scoop that the lubricator has no sand hole. Care must be exercised that all oil be wiped from feed regulating stems, nuts and center pieces or the steam would blow such oil on the scoop and it might lead to the belief that it came from a sand hole. This same precaution applies if the feeds are closed and the tests commenced immediately, as there would be oil adhering to the passages and nuts above sight feed chamber, which would be drawn down in a reverse direction by the current of steam escaping to the atmosphere through the vents, and must not be confounded with the oil that would

NO. 21.

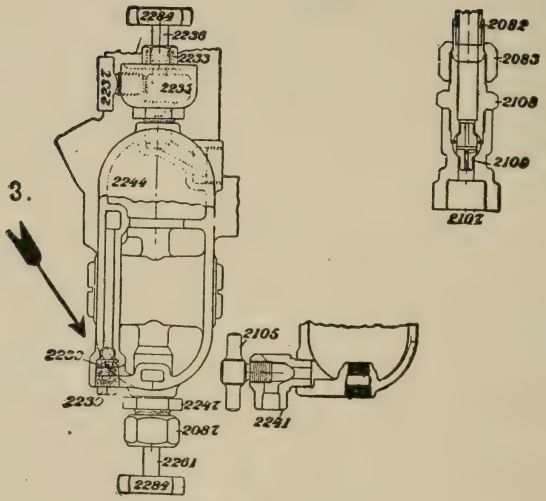

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Fig. 11.

escape through a sand hole if there was one. A loose feed cone or faulty seat would give the same results. Neither should this test be applied immediately after a lubricator has been filled with oil, especially if the oil be cold, as the expansion of oil, if great enough, would force all of the water and probably some of the oil back up through the water passage into the condenser, when the oil would be drawn down through the equalizing tubes into feed chamber, and in that event would show all the indications of a sand hole.

Any one of the above three methods are absolutely infallible when properly conducted.

EXPANSION OF OIL.—Oil taken at 60 degrees and heated to a temperature of 381 degrees (the temperature of steam at 200 pounds pressure) will expand 1-5 in volume. It will thus be seen it is of the greatest importance, that immediately after the lubricator is filled the water valve should be opened so as to allow the expansion to relieve itself through water tube and condenser, otherwise a tremendous pressure will be confined in the lubricator, which sometimes destroys the body.

Expansion of oil is invariably indicated by the rush of oil from the feed cones, the instant the feed stems are opened.

Allow the expansion to escape either through the feeds or drain off a small quantity of oil or water from drain stem No. 2105, otherwise the lubricator will feed irregularly until the expansion has been relieved. It must be understood the hotter the oil is before it is put in the lubricator, the less expansion there will be.

If the lubricator is reported hard to fill unless all pressure is shut off, the cause is a leaky stem seat which should be ground in or exchanged for any one of the feed stems. They are all alike and interchangeable.

The majority of lubricator troubles can be rectified by thorough blowing out; especially is this necessary when the engines are run in the pool system.

Never pound a lubricator. Such actions on the part of the enginemen indicate unfamiliarity with the principles, construction and care of a lubricator.

SYPHONING.

This is a condition that rarely takes place in any of the Modern Detroit Lubricators for the reason that all lubricators are protected with a ball check. (See Note C.) The word "syphoning" is less understood, and oftener misapplied when used in connection with a lubricator by the average engineer than any other word.

If the feeds race or feed faster after a locomotive is shut off and is drifting or at rest on account of enlarged chokes,

they claim or report "lubricator syphons." If the oil should steal away through a sand hole that is "syphoning." If on account of a loose feed cone, sediment gathered around base of feed cone, or a piece of glass lying against same, the oil feeds out by capillary action, that is "syphoning."

If the water tube in the old type of lubricators and also used in other types of bullseye lubricators, but not in the modern Detroits (see cuts), became loose or cracked where it screwed in condenser or top of lubricator and allowed the oil to transfer from body of lubricator to condenser, "syphoning" was responsible for that condition. If a lubricator was filled on the arrival at a terminal and some engineer who happened to be short on his allowance or was making a record by questionable means should draw off this oil, as almost every engineer knows has been practiced for some years past, the lubricator gets credit for "syphoning" out that oil that really was drawn into another oil can by a not too scrupulous person and put into another lubricator. More instances might be cited to show how the oil gets out of a lubricator. Any person who has given this well defined law of nature any consideration knows that in order to form a syphon it is essential to first create a vacuum, and a Detroit lubricator can only syphon out the oil under the following conditions:

First of all, the lubricator must be full or partly full of oil. Second, the steam valve on the boiler or the one on top of the condenser must be closed. Third, the water valve to lubricator must be open. Fourth, a vacuum must be created and in order to obtain that a locomotive must first be moved, steam shut off and then the locomotive must drift. The cylinders are then converted into air pumps while drifting, and the result is a vacuum is formed in oil pipes and lubricator condenser. The condition is now favorable for syphoning the oil out of a lubricator providing the water valve is open and there is no check in water tube or water passage (See Note C), or if there is scale or sediment above this check to prevent it from seating. If all these conditions are present at one time then oil could be syphoned out of the lubricator.

Some engineers make a practice of opening the water valve first before the steam valve, or of closing the steam valve before the water valve. This is a bad practice, especially when a locomotie is drifting, as it places a lubricator in a very favorable condition to syphon out the oil if it is not protected by a check.

CAUTION.—Always open steam valve first and water valve last at a terminal or elsewhere. Always close water valve

first and steam valve last. If these instructions are followed tnere never will be any occasion to report the lubricator syphoning, as a vacuum cannot be produced in the condenser and oil pipes when steam pressure is in the same.

NO. 21.

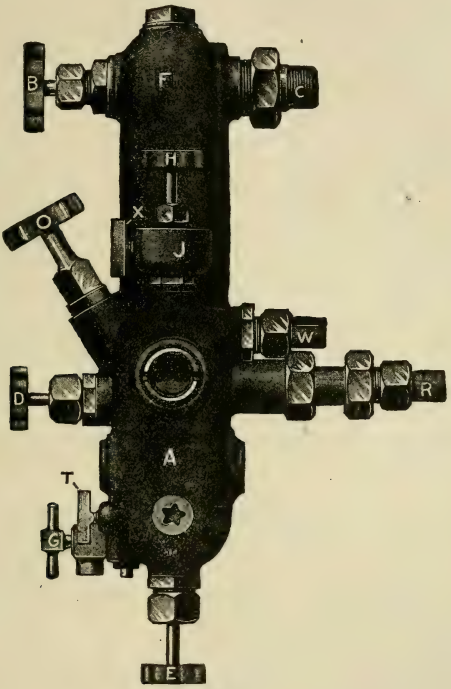


Fig. 12.

Expansion Chamber.—This is a feature that has been added to the No. 21 type of lubricator in order to provide a space for the expansion of oil, thereby relieving the body to some extent from that abnormal pressure when the lubricator is filled with cold oil, and at the same time prevent-

ing the oil from expanding back up into the condenser as it did in the old type of lubricator.

The expansion chambers vary in capacity according to the number of feeds: in No. 11, three ounces; in No. 21, four ounces; in No. 31, five ounces; in No. 41, six ounces. It should be remembered always that the hotter the oil before it is put in the lubricator, the less it will expand.

The practice of filling a lubricator full of cold oil at about 60 or 70 degrees temperature is condemned. If it is found necessary to use cold oil, owing to limited time or other conditions at the commencement of a trip, ¾ full is ample, as the oil will expand very rapidly as soon as the steam pressure is turned on the condenser and completely fill the remaining space, as has been noted elsewhere. The highest expansion of oil is about 1/5 of its original bulk. In other words, oil contracts as it cools and expands as it heats.

POINTS TO BE REMEMBERED IN OPERATING LUBRICATORS.

That a lubricator will give better results if it is cared for intelligently.

That the water passage will close up with sediment and cut off the water between condenser and oil reservoir as completely as if the water valves be closed.

That a lubricator should be blown out at least once a week, and in bad water districts, oftener.

That a piece of soap put in the reservoir about once a week will keep it clean, also the glasses.

That valve oil and engine oil should never be mixed and put in a lubricator. The temperature

of the lubricator is too great for engine oil; besides, the engine oil will carbonize. As soon as it passes up and out of sight feed chamber it comes in contact with the high steam temperature and all lubricating properties have been destroyed.

That particles of carbonized engine oil have no more lubricating properties than powdered charcoal would have.

That if your valve oil supply is not sufficient to reach a terminal point at the regular rate of feed, feed the lubricator slower, carry less water. Don't wet the valves; run with a lighter throttle, a longer cut-off, and do not allow your engine to drift into town or down hill, but work a very light throttle.

That the chokes at the steam chest are constantly cutting away by the action of the steam.

That the chokes balance a lubricator.

That the steam-valve on a boiler and on the one on top of the condenser must be opened wide in order to counteract the two steam-chest pressures.

That there are a limited number of drops of valve oil in one ounce, one pound, one pint, and a lubricator.

That the quantity of oil per mile increases as the speed of a train decreases, and it correspondingly decreases as the speed of the train increases.

That as the engine is running very slowly on a hill the lubricator is increasing the quantity of oil per mile in proportion to the speed.

That salt water is more buoyant than fresh water, and for that reason it will force the drop of oil off the feed cone sooner. There would be more drops of oil in a minute than when the water

in the sight feed chamber was fresh, but the quantity of oil would not be any less.

That the water in the sight feed chamber becomes salty and it is carried over from the boiler by the mechanical action of the steam.

That there is a constant evaporation taking place in the condenser of any kind of locomotive lubricator. The same is true in the outlet of the sight feed chamber.

That there are two principles involved in a locomotive lubricator. First—Hydrostatic: The hydrostatic pressure ends on the point of the feed cone. From that point to the surface of the water in the sight feed chamber, the oil travels at the rate of 30 feet per minute. Second—The oil coming in contact with the steam is carried to the steam-chest by the laws of gravity, heat and motion.

That the chokes at the steam-chest give better results. That the boiler pressure reaches down to the steam-chest, chokes and prevents back pressure from backing up into the oil pipe; also, the lubricator is feeding against a constant boiler pressure, and not against a fluctuating oil pipe pressure as when the chokes were located at the lubricator.

That the oil should be strained.

DETROIT LOCOMOTIVE LUBRICATOR NO. 22. BULL'S-EYE PATTERN.

The Detroit No. 22 lubricator is almost identical with the No. 21. One novel thing in this lubricator, however, that is not found in the No. 21 is the introduction of an oil valve in the oil passage between the reservoir and the sight feed regulating valves which places in the hands of the operator an instantaneous means of starting, stopping or throttling the rate of feed, and does away with the necessity of shutting off the feed regulating valves

at a terminal or in refilling on the road, and consequently the necessity of opening and readjusting these valves after refilling or at the commencement of the service movement.

This oil valve has a lever handle and index plate, and is so designed that from the "Closed" position, a half turn will open all feeds, or a quarter turn the feed to air pump only, and vice versa.

In adjusting the feed regulating valves of a lubricator, the practice differs, the usual custom being to race the feeds and gradually throttle, which means a waste of oil on account of the cold condition of the steam chest and cylinders and washing action of the heavily saturated steam during the initial movement. Another practice, attended also by decreased oil mileage and even more harmful results, is that of starving the valves and cylinders through insufficient lubrication, due either to error in judgment on the part of the operator as to the number of drops per minute at which he should set the feeds, or through not starting the lubricator in sufficient time before leaving the terminal. This practice will result in distortion of the valve motion through dry valves, waste of fuel, loss of time and speed and the necessity of racing the feeds in order to get the valves back into proper working condition.

The use of the oil valve, the regulating valves having been once adjusted, makes the starting of this lubricator an instantaneous operation and insures the correct amount of lubrication. The operator knows that as soon as the lubricator has reached its proper temperature, the oil will feed at the rate required.

The adjustment of the lubricator feeds in night service or where the device is inconveniently located is always a matter of more or less difficulty. As the oil valve does away with the opening and closing of the regulating valves and the necessity for observing the sight feed features when starting and stopping the

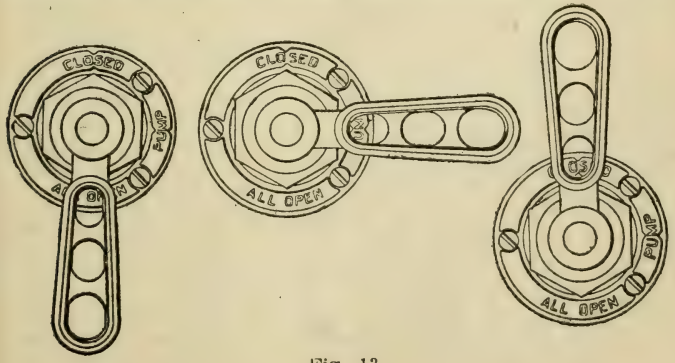


Fig. 13.

device, it becomes a great convenience to the operator, as under all conditions, night or day, he can by the sense of touch alone, place the lever handle of this valve in any one of its three positions shown in Fig. 13.

The differences between the No. 22 lubricator and the No. 21 are as follows:

An oil valve has been introduced to perform the functions of the feed regulating valves in starting, stopping or throttling the device, except that it does not control the amount of oil delivered from each nozzle until the regulating valves have been set. This valve has a lever handle and index plate on which are shown three positions: "Closed," "Pump," and "All open." In the "Closed" position of the valve, the valve handle is vertical and pointing upward. All feeds are shut off. In the "Pump" position, the handle is horizontal and pointing to the right, and the air pump feed alone is working. In the "All open" position, the handle is vertical, pointing downward, and all feeds are working.

The oil tube and bushing formerly used in this type of lubricator have been done away with and the oil passage is now a drilled passage in the front wall of the reservoir, so that there are no removable tubes in the lubricator, thus doing away with the possibility of a failure through their becoming loosened.

A small ball check has been put in the oil feed nozzle which is claimed to prevent, through the improper closing of the steam valve before the oil valve, the loss of oil from the reservoir due to equalization of pressure. This check valve will also permit, in case of stoppage or an obstruction in the oil nozzle, blowing out of such obstruction by closing the oil valve and removing the center piece of the feed affected. The ball check can then be raised by a small wire. The placing of a check at this point is claimed to prevent the passage of the water from the sight feed chamber into the lubricator, and that the water in the sight feed chamber remains much clearer than was otherwise the case.

The oil valve controls the passage between the sight feed regulating valves and the oil reservoir. Consequently, if it becomes necessary, while the lubricator is under pressure, to make any repairs to the regulating valves, the closing of the oil valve will avoid the necessity for draining the reservoir.

Operation.—Always start lubricator about 15 minutes before leaving the terminal. Be sure that the regular boiler valve is open, then open wide steam valve "B," Fig. 14, at the top of the condenser and keep wide open while the lubricator is in operation. Allow sufficient time for condenser and sight feed glasses to fill with water and then open water valve "D." Then open valve "C."

In adjusting the lubricator feeds for a class of service after oil valve "C" is opened, regulate the cylinder and pump feeds by means of valves "E," "E" and "L." After these valves

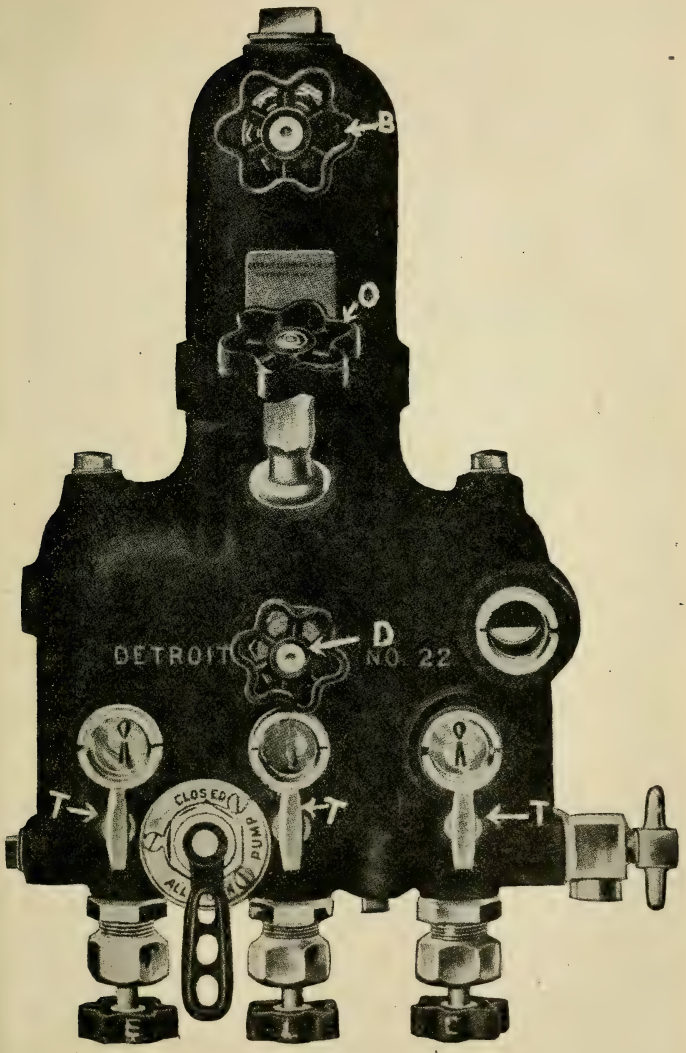


Fig. 14.

have been once adjusted, do not use them in the ordinary operation of the lubricator.

Setting Feeding Valve.—Adjust the feed valves to the maximum number of drop required for the hardest level track service in the class. Then the number of drops can be decreased for the lighter service by throttling with oil valve. For short stops, close oil valve "C" only.

In shutting down the lubricator, for short stops, close oil valve "C" only. For terminal stops, close oil valve "C" first, then water valve "D" and last the steam valve "B."

To Fill or Refill.—Move oil valve "C" to "Closed" position, close water valve "D" and steam valve "B." Open drain valve "G." If lubricator is not under pressure, remove filler plug slowly to allow pressure above the oil to escape and the air to enter. Fill the reservoir full. If there is not sufficient oil for this purpose, use water to make up the required quantity. This method will enable the feeds to start without exhausting the water from the condenser or materially lowering its level.

Steam Valves.—The regular boiler valve should be left wide open at all times and the steam valve "B" at the top of the condenser must be left wide open while the locomotive is in service.

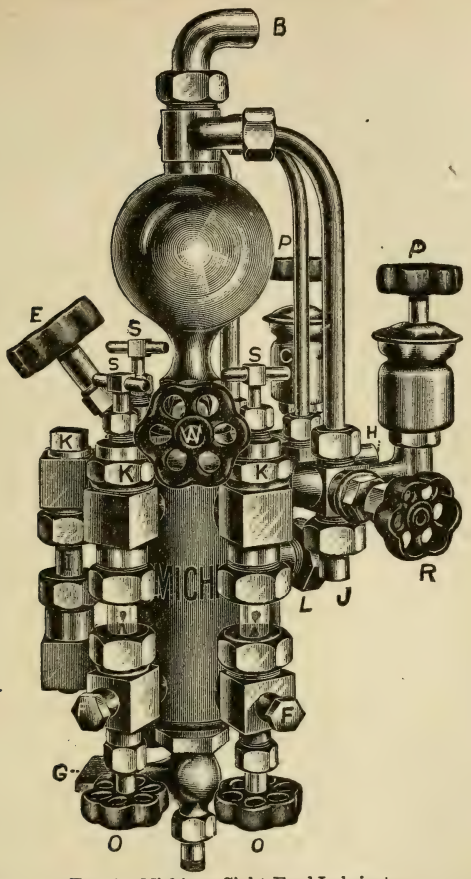


FIG. 1. Michigan Sight Feed Lubricator.

A—Lock Nut to secure Lubricator to Angle Iron.
B—Union to connect Pipe for admission of steam.
J-J—Unions to connect Cylinder Feeds to Tallow Pipes.
H—Union to connect Air Pump Feed.
N—Steam Valve for Boiler Pressure. (Not shown.)
E—Filler Plug.
W—Valve to admit water from Condenser to Oil Reservoir.
O-O-O—Regulating Feed Valves.
C-C—Auxiliary Oilers operative with Throttle open or closed.
P-P—Auxiliary Oiler Filler Valves.
R-R—Auxiliary Oiler Feed Valves.
S-S-S—Lifting Stems to hold Automatic Check Valves off their Seats so Glasses will fill with Water of Condensation when empty.
F-F-F—Valves to drain Sight-Feed Glasses without emptying Oil Reservoir.
K-K-K—Removable Plugs for renewing or cleaning Sight-Feed Glasses.
I—Gauge Glass.
G—Valve to drain Oil Reservoir.

MICHIGAN SIGHT-FEED LUBRICATOR.

The manufacturers of this lubricator claim to overcome the "hold-up" of oil in the tallow pipes, and to insure a delivery of oil direct to the steam chest with wide open throttle and any position of reverse lever.

The principle by which it is claimed that this "hold-up" of oil in the tallow pipes is prevented is shown in Fig. 2, which illustrates the automatic

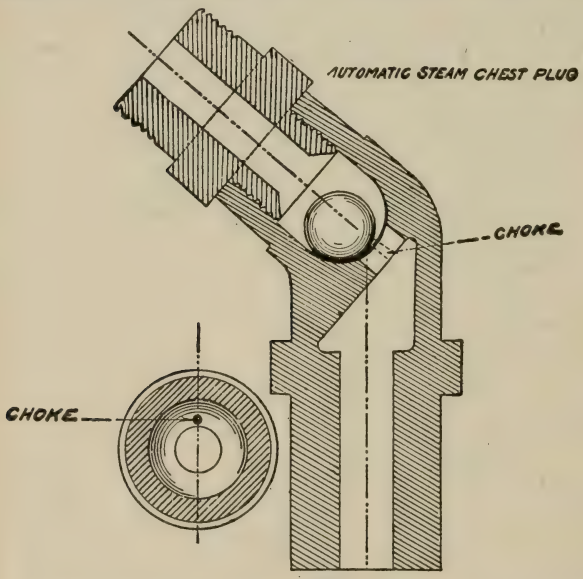


FIG. 2.

Vertical longitudinal section of Michigan automatic steam chest plug, showing the large area and its ball valve, associated with a constant choke at the side thereof.

steam chest plug. This device has a ball valve, the seat of which is about equal in area to the inside of the

tallow pipes of the locomotive, and having at one side of this seat the choke opening. The cylinder feeds *JJ*, Figs. 1 and 3, have no chokes within the lubricator. Hence a full current of steam is delivered from the boiler through the steam tube, condenser, equalizing tubes and tallow pipes to these automatic plugs at each steam chest, thus giving a complete steam area from the boiler to the steam chest about equal to that of the tallow pipes. Consequently, when the locomotive throttle is wide open, the forward pressure from the lubricator practically equalling the back pressure from the steam chest, the ball in the steam chest plug drops by gravity from its seat to the position shown in Fig. 2.

All pressures now being equal, oil will flow by gravity into the steam chest at the same intervals it is seen feeding in the sight-feed glass.

The instant the boiler (or forward) pressure becomes greater than the steam chest pressure, as when the engine throttle is closed, the ball valve in the steam chest plug is forced to its seat, leaving only the small choke at the side of the ball seat open, and thus maintaining a balance of pressure in the intake and outlet pipes of the lubricator. These steam chest plugs should always be screwed perpendicularly into the top of the steam chest.

Another special feature of this valve is the arrangement whereby oil may be supplied through the auxiliary oilers (*CC*, Figs. 1 and 3) without closing the locomotive throttle, as clearly shown in Fig. 3.

Another noticeable feature of this lubricator is the automatic check valves at the top of each sight-feed glass, as shown in Fig. 4. These valves are

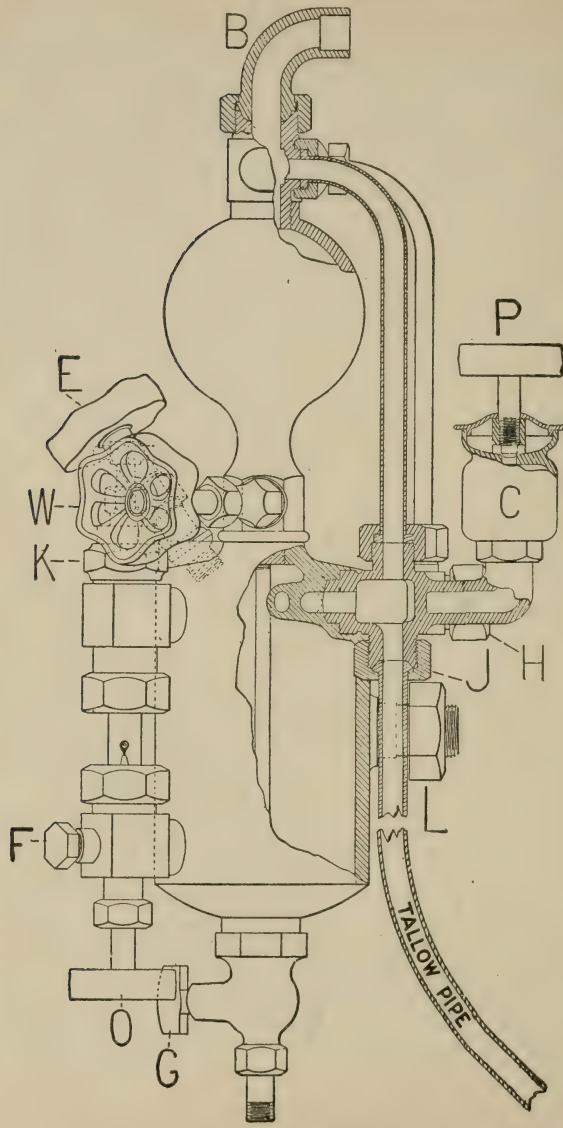


FIG 3.

Michigan Sight Feed Lubricator.
Side elevation, part in vertical longitudinal section.

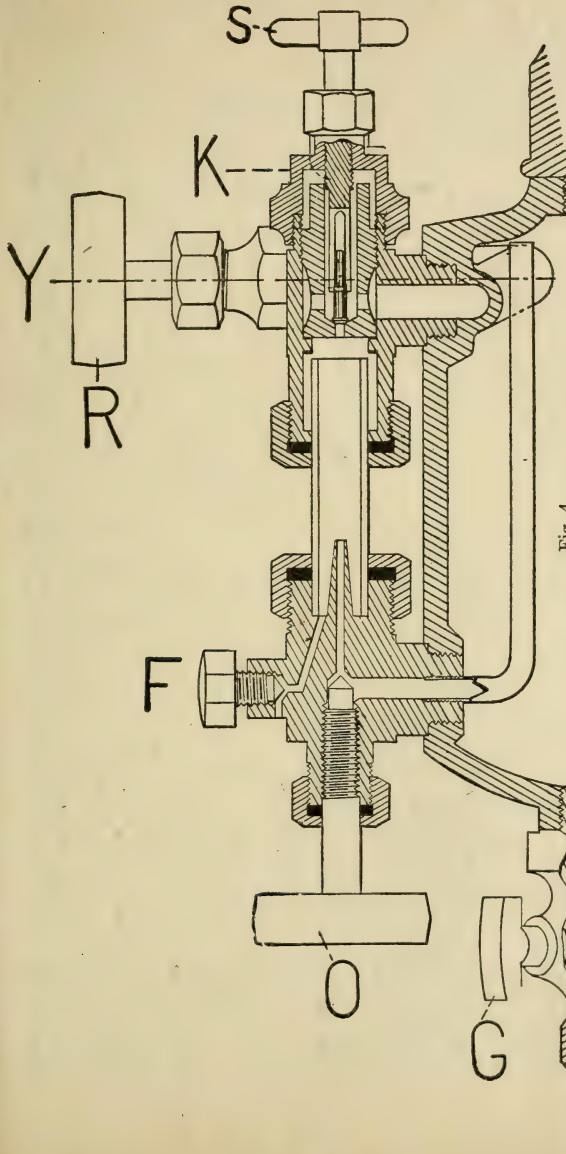


Fig. 4.
Michigan Sight Feed Lubricator.

Front elevation part in vertical longitudinal section, showing internal arrangement of auto positive check valves top of sight feed glass, and drain valve F at the bottom thereof.

suspended in the stems *SSS* (see also, Fig. 1), which, when screwed down, leave the check valves free to close automatically should the sight-feed glasses break. When it is desirable to open the sight-feed drain valves *FFF* to renew the water of condensation in any one glass while the others are still operating, unscrew the lifting stem *S* a few turns, thus holding the check valve off its seat and permitting steam to blow through. As soon as the glass is blown out, close the valve *F*, and fresh water will immediately fill the glass; then screw down on the lifting stem *S*, and the check is again automatic.

To operate.—Open steam valve *N* full for boiler pressure, then open valve *W*, and regulate feed of oil by valves *OOO*, observing not to start feeding until the condenser and sight-feed glasses have had time to condense full of water.

Shutting off lubricator.—In leaving engine after a trip, close the sight feeds first and the steam valve last, leaving water valve *W* open, in order that the expansion caused by heating freshly filled oil will ease off through the tallow pipes, thus preventing the expansion, strain or bulging of the lubricator.

To operate the auxiliary oilers.—Close the auxiliary feed valve *R* perfectly tight, and open its oil feeder valve *P* a turn or two, fill the cup with oil, close tightly valve *P*, and finally open valve *R*, thus permitting the oil to pass directly into tallow pipes, as shown in Fig. 3.

Blowing out lubricator.—The method of renewing the water of condensation in the sight-feed glasses has already been given.

Should the passage from the top of the sight-feed

nipple to the top of the internal oil delivery arm (in reservoir) become clogged, this can be blown out with live steam by emptying the oil reservoir and leaving the feed valve *O* and reservoir drain valve *G* open. (See Figs. 1 and 4.)

NATHAN TRIPLE SIGHT-FEED "BULL'S-EYE" LUBRICATOR, NO. 9.

In this lubricator the disc glass, Fig. 2, is used, which is claimed by the manufacturers not to break under any condition of service. All the glasses of this disc are packed in casings which screw into the body, making their removal for inspection or repairs easy.

With this lubricator a cylindrical form of reservoir is used and hand oilers are provided for the cylinder feeds with gauge glasses to indicate when the reservoir is nearly empty. Also a reserve glass R, Fig. 1, packed in its casing is carried for use whenever occasion requires it.

Directions for Application.—This lubricator should be secured to the boiler head or top of boiler, in the usual manner with connections, for steam to fountain or turret, if large enough, otherwise direct to the boiler. The steam pipe must not have less than ¾-inch I. D. when iron pipe is used, and not less than ⅝-inch I. D. when copper pipe is used. Steam valves and their shanks must have openings fully in accordance with these dimensions. Oil pipes must have a continuous fall toward the steam-chest, without any "pockets" in them.

Directions for Use.—Fill the cup with clean, strained oil through filling plug "A," and immediately after filling, open water valve "D." Open steam valve (not shown), wait until sight-feed chambers are filled with water, then start and regulate the feed by opening regulating valves "C," more or less, according to the feed desired.

To Stop Either of the Feeds.—Close the respective regulating valve "C."

To Renew Supply of Oil.—Close all valves marked "C," and valve "D," draw off water at waste cock "W," then fill the cup as before, and open water valve "D," immediately after filling, whether the feed is started again or not.

To Oil by Hand.—Close all valves. Fill the hand oilers "O," open the hand oiler valves, and when all the oil has entered the tallow pipes, close hand oiler valves and open valves as before.

Always open the steam valve before the engine begins to do any work whatever, whether the feed is started right away or not, and keep it open as long as the engine is doing service of any kind.

Always keep the water valve "D" open, except during the period of filling the cup, as per direction.

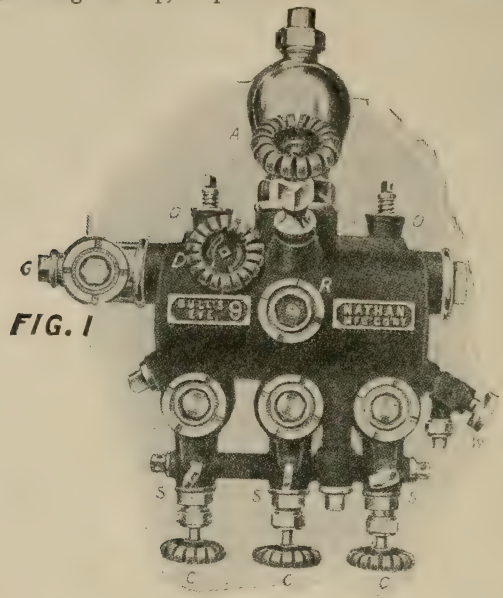


FIG. 1

FIG. 1.

A, Filling Plug; C C C, Regulating Valves; D, Water Valve; G, Gauge Glass; O O, Hand Oilers; R, Reserve Glass; S S S, Sight-feed; W, Waste Cock Drain Valves.

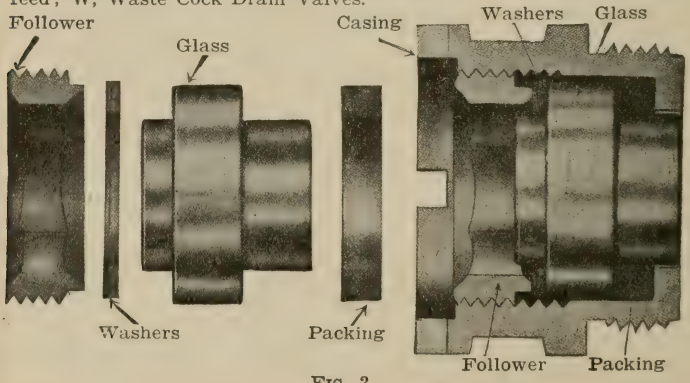


FIG. 2.

Once in two weeks at least, blow out the cup with steam, opening all valves wide with the exception of the filling plug, which should remain closed.

When putting on the lubricator for the first time, or after it has been off for repairs, follow up the packing nuts of the glasses, when the lubricator gets hot, so as to take up any slack caused by expansion. This will tend to keep the joints tight.

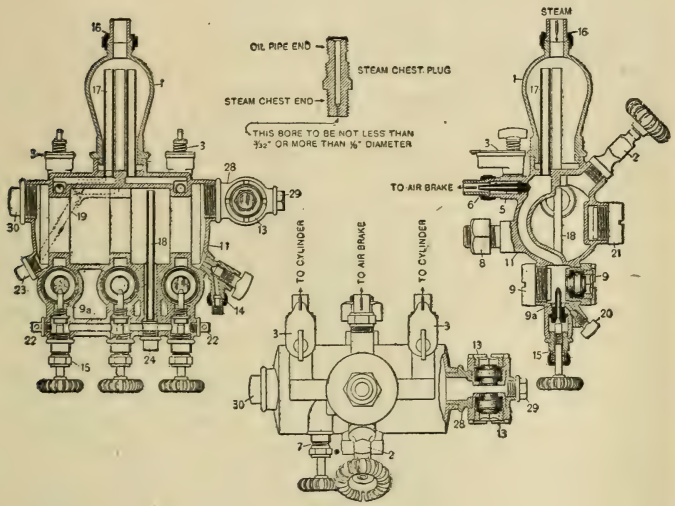


Fig. 3.

LIST OF PARTS.

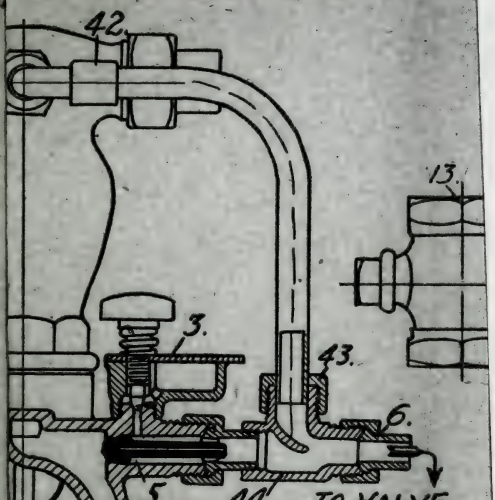
1. Condenser.
2. Filling Plug.
3. Hand Oiler.
5. Reducing Plug.
6. Delivery Nut and Tailpiece.
7. Water Valve.
8. Stud Nut.
9. Sight-feed Glass and Casing.
9a. Feed Nozzle.
11. Body.
13. Gauge Glass and Casing.
14. Waste Cock.
15. Regulating Valve.
16. Top Connection.
17. Equalizing Pipe.
18. Oil Pipe.
19. Water Pipe.
20. Sight-feed Drain Valve.
21. Reserve Glass and Casing.
22. Cleaning Plug (Body).
23. Body Plug.
24. Oil Pipe Plug.
28. Gauge Glass Bracket.
29. Cleaning Plug (Gauge Glass).
30. Gauge Glass Cap.

NATHAN THREE-FEED TYPE BULL'S-EYE LOCOMOTIVE LUBRICATOR.

The auxiliary steam valve (parts 38-39) is not an operating valve for the lubricator, but controls only the admission of steam to the auxiliary steam pipes leading from the condenser to the oil delivery pipes.

In connection with locomotive engine lubrication it develops occasionally, particularly with the use of superheated steam, that under very severe conditions, the feed of the lubricator is retarded by the back pressure from cylinders or steam chests, and the engine, under those conditions, does not obtain sufficient lubrication. It is useful and desirable under such conditions to admit a supply of steam into the oil pipes, in addition to that ordinarily passing through the choke plugs, to assist the delivery of oil to the valves. This desirable purpose is accomplished in the Bull's-Eye lubricator with auxiliary steam pipes.

Pipes 140 lead from a suitable point at the top of the condenser into the oil pipes to the steam chests. These pipes connect with the oil pipes ahead of the choke plugs. Steam admission to these pipes is controlled by a valve 138 which is not an operating valve for the lubricator itself, but controls only admission of steam to the auxiliary pipes 140. This is used intermittently as occasion requires. Any type of Bull's-Eye lubricator may be provided with auxiliary steam pipes. With this lubricator, when desired, an oil cut-out valve 56 is furnished, unless so specified, however, a plain cap 79 is supplied in place of same. This oil cut-out valve 56 is of the regular screw motion type, to be turned to the left for opening and to the right for closing same, and cuts out when closed, all the feeds except the air pump feed. In all other respects the lubricator is of standard construction and is operated in the usual manner.



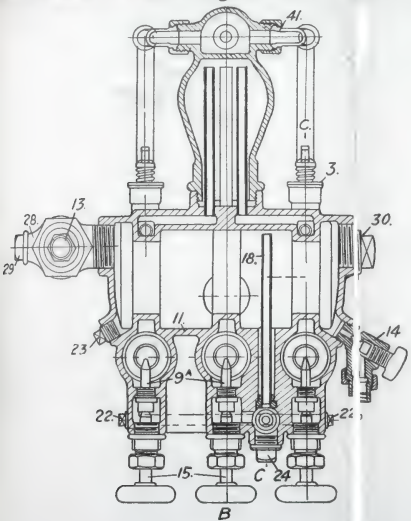
Names and Nu

1. Condenser
2. Filling Plug
3. Hand Oiler
5. Reducing Plug
6. Delivery Nut & T
7. Water Valve
8. Stud Nut
9. Sight-feed Glas
9A. Feed Nozzle
11. Body
13. Gauge Glass & C
14. Waste Cock
15. Regulating Valve
16. Top Connection
17. Equalizing Pipe
18. Oil Pipe
19. Water Pipe
20. Sight-feed Drain
21. Reserve Glass &
22. Cleaning Plug (L
23. Body Plug
24. Oil Pipe Plug
26. Support Stud
28. Gauge Glass Bl
29. Cleaning Plug (g

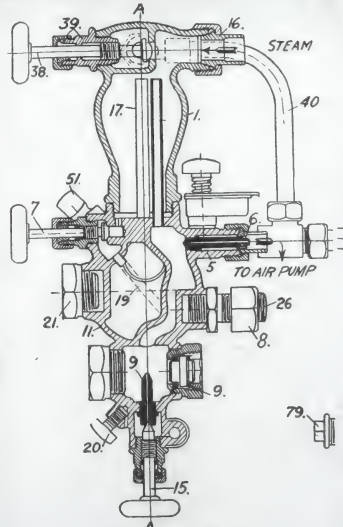
v C-C.

The lubricator (parts 38-39) is not an operating valve for the lubricator, but controls only the admission of steam to the auxiliary steam pipes leading from the condenser to the oil delivery pipes. With this lubricator, when desired, an oil cut-out valve 56 is furnished, unless otherwise specified, so plain cap 79 is supplied in place of same. This oil cut-out valve 56 is operated by the regular screw cap 79, to be turned to the left for opening and to the right for closing same, and when turned out when closed, all the feeds except the air pump feed

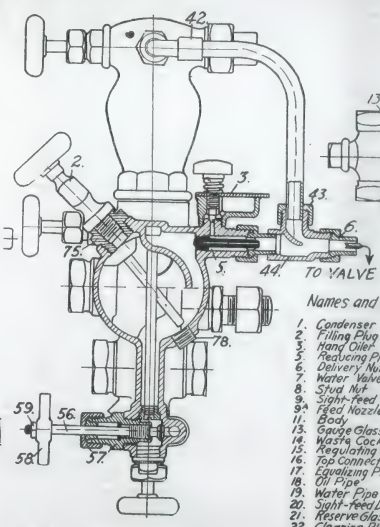
In all other respects the Lubricator is of Standard construction and is to be operated in the usual well known manner.



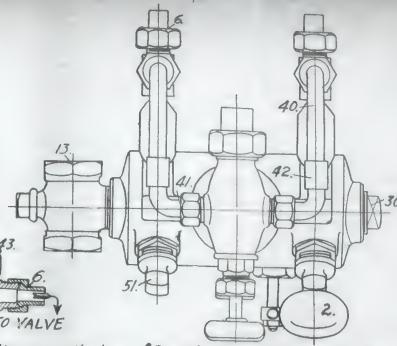
SECTION A-A.



SECTION B-B.



SECTION C-C.



Names and Numbers of Parts for Reference in ordering Repairs.

1. Condenser
2. Filling Plug
3. Hand Oiler
5. Restoring Plug
6. Delivery Nut & Tailpiece
7. Water Valve
8. Stud Nut
9. Sight-Feed Glass & Casing
9A Feed Nozzle
11. Body
13. Gauge Glass & Casing
14. Waste Cock
15. Regulating Valve
16. Top Connection
17. Equalizing Pipe
18. Oil Pipe
19. Water Pipe
20. Sight-Feed Drain Valve
21. Reserve Glass & Casing
22. Cleaning Plug (body)
23. Body Plug
24. Oil Pipe Plug
26. Support Stud
28. Gauge Glass Bracket
29. Cleaning Plug (Gauge glass)
30. Gauge Glass Cap
38. Auxiliary Steam Valve Spindle
39. Auxiliary Steam Valve Bonnet & Nut
40. Auxiliary Steam Pipe
41. Elbow Connection } For Auxiliary
42. Connecting Nipple } Steam Pipe
43. Packing Nut
44. T Connection
51. Plug for Filling Hole
56. Oil Cut-out Valve Spindle
57. Oil Cut-out Valve Bonnet & Nut
58. Oil Cut-out Valve Handle
59. Oil Cut-out Valve Handle Nut
75. Removable Seat for Filling Plug
78. Plug for Water Pipe
79. Cap for Plugging Oil Cut-out Valve

NATHAN MFG CO. NEW YORK, N.Y.

3 FEED TYPE 166-F-3

BULL'S-EYE

LOCOMOTIVE LUBRICATOR

WITH AUXILIARY STEAM PIPES

FROM CONDENSER TO OIL DELY PIPES

THE CHICAGO LUBRICATOR, CLASS "C"—THREE AND FIVE FEEDS WITH SOLID GLASSES.

This lubricator is designed for use on balanced compound and other engines where more than three feeds are required. It gives five oil pipe connections and feeds. It occupies only the space required for a three-feed lubricator. It is claimed that in this design the detachable joints have been much reduced, with corresponding reduction in cost of repairs. The feed arms are cast solid to oil bowl. The feeds are entirely independent, and any one of them can be shut off to renew gaskets or glasses, without interfering with the other feeds, by closing pressure valve No. 62 and feed valve No. 31 or 95, and opening drain valve No. 33. The separate oil supply for each feed valve obviates a single oil pocket for all feeds. There are no inside pipes to get out of order, and all pipes for steam circulation are outside, convenient in case of steam leaks. The arrangement of pipes takes the intense heat from the condenser and oil bowl, preventing loss of lubricant as in the case when the oil is heated to a high temperature. Pressure valves protect the engine crew in case of glass gasket blowing out. Oil is delivered to the engine valves as fast as it is fed from the lubricator. The feed is always regular, and will not vary unless there is an obstruction in the passage of lubricator. It will not siphon, because of check valve No. 4 interposed between steam supply and condenser.

Auxiliary oil cup No. 65 is a pressure cup and is in direct connection with the oil pipe through upper feed arm over the seat made by pressure valve No. 62, and can be filled and operated without closing the engine throttle or lubricator steam valve.

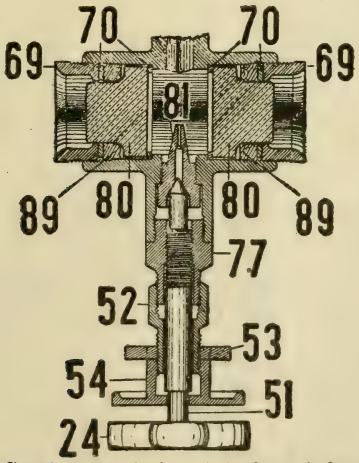
The following is a list of the parts of the "Chicago" Lubricator, and reference to the numbers given on the list and the illustrations following will fully explain its construction:

4. Check Valve.
6. Pipe Union nut for steam chest circulating pipe.
7. Pipe Union nut for air pump circulating pipe.
8. Steam Supply union.
9. Steam Supply nipple.
10. Cap plug for pipe T, Nos. 74 and 91.
23. Filler plug.
24. Handle for valve stem.
30. Feed Valve packing nut.
31. Feed Valve.
33. Drain Valve.
34. Drain Valve plug for oil bowl.
35. Tallow pipe union (nut and nipple).
36. Choke plug for air pump feed.
38. Mounting stud lock nut.
51. Feed Valve with regulating attachment.
52. Packing nut for regulating attachment.
53. Jam nut for regulating attachment.
54. Auxiliary handle for regulating attachment.
55. Cap for steam chest valve No. 3.
56. Casing for steam chest valve No. 3.
57. Valve for steam chest valve No. 3 or 3-A.
62. Pressure valve and nut.
63. Cap plug ⅝".
64. Pipe plug ½".
65. Auxiliary oil cup.
66. Auxiliary oil cup Filler Plug.
67. Cap plug ⅞".
68. Oil pipe bushing for air pump feed supply.
69. Packing nut for glass.
70. Follower ring and washer for solid glasses.
71. Condenser (3-feed).
72. Oil bowl for 3 or 5 feed.
73. Water Valve.

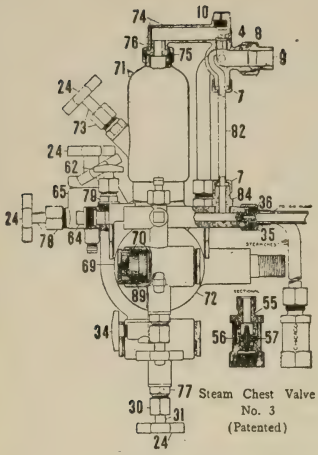
74. Pipe Connecting T (3-feed).
75. Connecting nut for Nos. 74 and 91.
76. Ball joint for Nos. 74 and 91.
77. Feed Valve Hub.
78. Auxiliary Oil Cup feed valve complete.
79. Pressure Valve Hub.
80. Solid glasses for feed pocket or index.
81. Feed Tip.
82. Circulating pipe for air pump.
83. Circulating pipe for steam chest.
84. Pipe Hub air pump and low pressure circulating pipes.
85. Pipe Hub for steam chest circulating pipe.
88. Auxiliary Oil cup drain valve.
89. Gaskets for solid glasses.

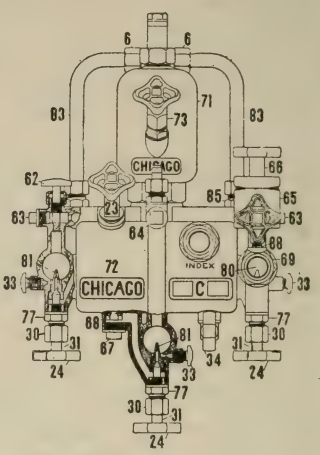
ADDITIONAL PARTS FOR FIVE FEED LUBRICATOR.

90 Condenser for 5 feed.
91. Five-feed pipe T.
92. Secondary pipe T.
93. Circulating pipe for low pressure.
94. Circulating pipe for high pressure.
95. Feed Valve, low pressure.
96. Feed Valve hub, low pressure.

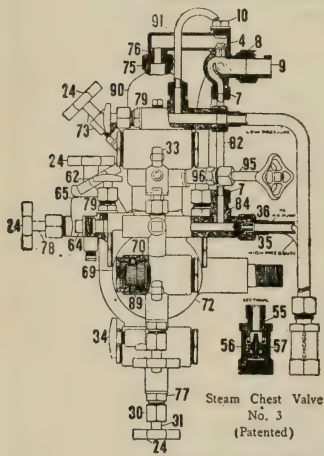


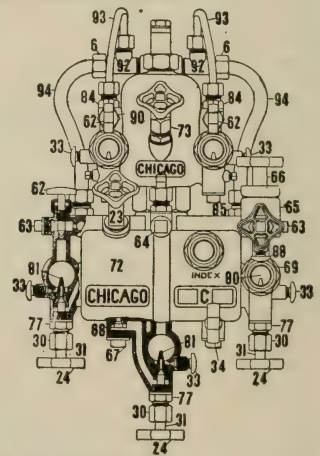
Special Regulating Attachment for Locking Feed Valve—Chicago Class C Lubricator.





CHICAGO CLASS C, THREE FEEDS, WITH SOLID GLASSES





CHICAGO CLASS C, FIVE FEEDS, WITH SOLID GLASSES

FORCE-FEED LUBRICATORS.

For many years past individual unit, force-feed lubricating devices have come to supersede all others in power plants where modern and economical practice prevails.

At the present time of very fast trains, making long runs between stops, the question of facilities for thorough and positive lubrication of all journals, eccentrics and links of the fast moving engine becomes very important.

McCORD FORCE FEED LUBRICATOR.

The McCord system of force feed lubrication is designed on the theory that the most efficient method of lubricating a locomotive is to deliver the lubricant automatically, positively and in proportion to the work the locomotive is performing.

The system is applicable to valves, cylinders and air pumps using valve oil, or to driving boxes using engine oil, or both actuated by the same or differently arranged driving mechanism in the same or different reservoirs. Where the valve oil for the valve cylinders in air pump and engine oil for driving boxes is delivered from the same reservoir, the reservoir is partitioned with valve oil on one side and engine oil on the other.

The lubricator proper consists of individual, vertically, operating plunger pumps for each feed set in the reservoir, which is usually located in the cab of the locomotive, but is sometimes located in the cylinder saddle. Eccentrics submerged in the oil in the reservoir on the horizontal shaft through the reservoir operate the plunger pumps. The pumps are made in two different styles—the double plunger sight feed as shown in Fig. 1, and the single plunger bleeder test feed, shown by a sectional view in Fig. 2. The latter which is superseding the former, is a simple single acting pump with ball check valves which seat by gravity, the bleeder feature replacing the sight feed arrangement of the double plunger pump.

The pump plunger A, Fig. 2, is moved up and down in the

cylinder of the pump body B by means of the eccentric C, on the horizontal shaft D. The ball check valves E raise on the up stroke and admit oil under the plunger. On the down stroke the checks E seat and the oil is forced up by the check valves F, and out into the oil line. At the end of the down stroke the checks F seat. The bleeder valve G can be opened by hand at any time it is desired to determine the amount of feed. The length of stroke of the plunger A governs the amount of oil feed, and is regulated by the ring nut H, which is locked by the knurled nut J. There is a strainer at the filling hole of the lubricator and at the bottom of each suction pipe K. Each feed can be adjusted independently and operated independently by hand or all the feeds can be operated by hand by turning crank, illustrated to the left in Fig. 1, without interfering with the regular working of the lubricator, before or after.

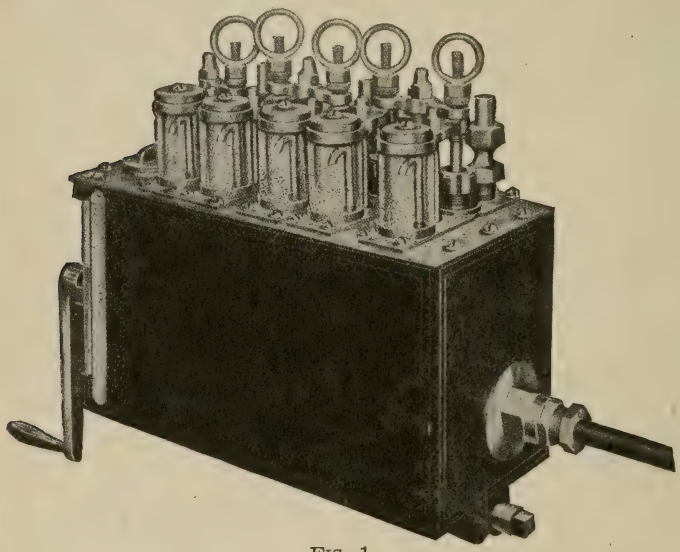


FIG. 1.

The circular motion of the lubricator eccentric shaft is obtained from the motion of the valve stem of the locomotive. This reciprocating motion is changed to a rotating motion by a transformer, see Figs. 3 and 4, composed of a ratchet and two beveled gears. The ratchet D, Fig. 3, is keyed to one of the beveled gears I, Fig. 4, and the pawls E on the ratchet are connected to an arm

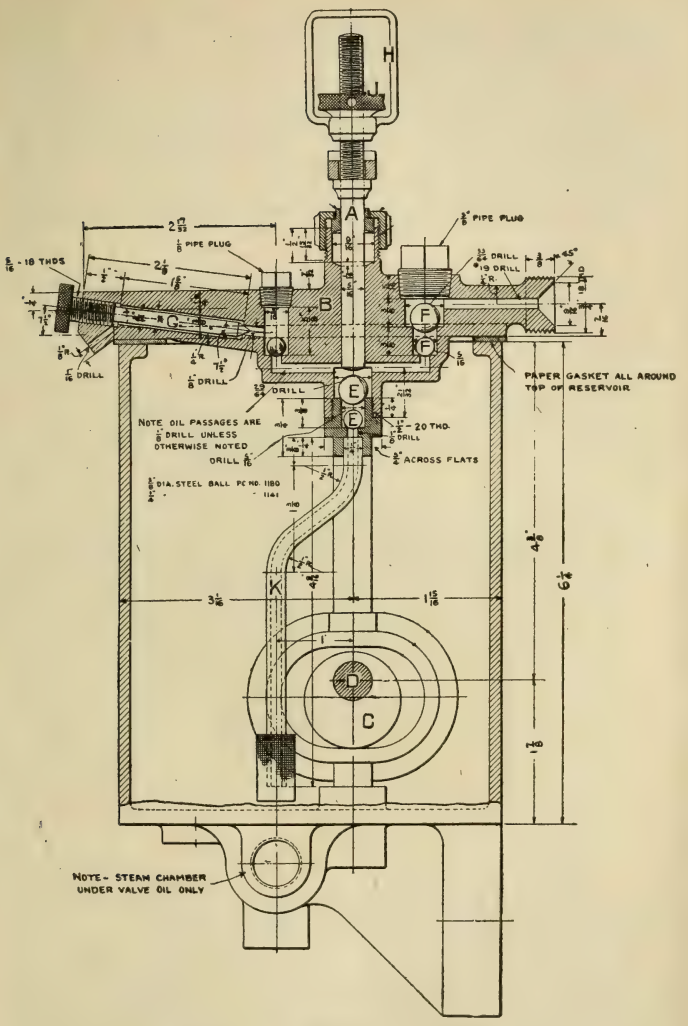


FIG. 2.
McCord Force Feed Lubricator.

B which extends through the transformer casing and is attached to lever A, connecting with the valve stem. As the latter moves back and forth, it slowly revolves the ratchet wheel D and by means of the bevel gear I and J, the transformer shaft K is slowly turned. From the transformer the motion is transmitted to the lubricator by a shaft usually made of iron pipe (used in place of a solid rod), which, with one universal joint at the transformer and one other at the lubricator, takes care of the difference in positions of the transformer and the lubricator. This transformer may be located on the running board or on a bracket

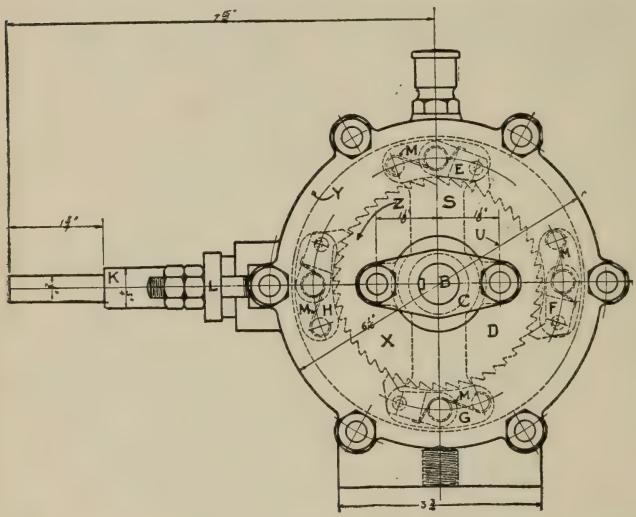


FIG. 3.

on the boiler where convenient attachments can be made to the lubricater proper and to the valve gear of the engine.

The oil is conveyed from the lubricator through copper tubing of ⅛-in. inside diameter, ¼-in. outside diameter, and given to the valves or driving boxes through a gravity terminal check valve shown in Fig. 5. The driving box terminal check valve is screwed into the driving box, connecting to the horizontal channel, thence to a vertical channel to the brass. A flexible steel pipe is used

to allow for the vertical motion of the driving box. The gravity valves keep the pipes full of oil at all times so that the smallest movement of the plungers emits just that much oil out of the other end of the pipe.

The pumps are capable of pumping against a pressure of over 3,000 lbs. per square inch, so there is practically no pressure on the locomotive that can interfere with the oil being forced to the proper bearing.

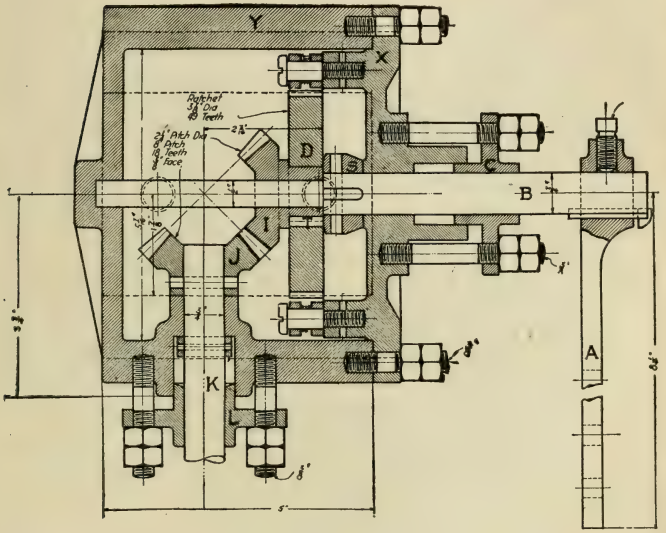


FIG. 4.

The main check valves and the driving box check valves operate by gravity on the same principles, the only difference is in their size.

By sealing the top of the driving boxes this system utilizes the accumulative pressure generated by the revolving journal in the cavity of the crown of the brass to increase the thickness of film of oil that separates the bearing surfaces of the journal

and the brass, thus by pumping a film of engine oil through this cavity into the bearing, the driving box is claimed to be raised off from the journal thus permitting the journal to run in practically a floating bearing.

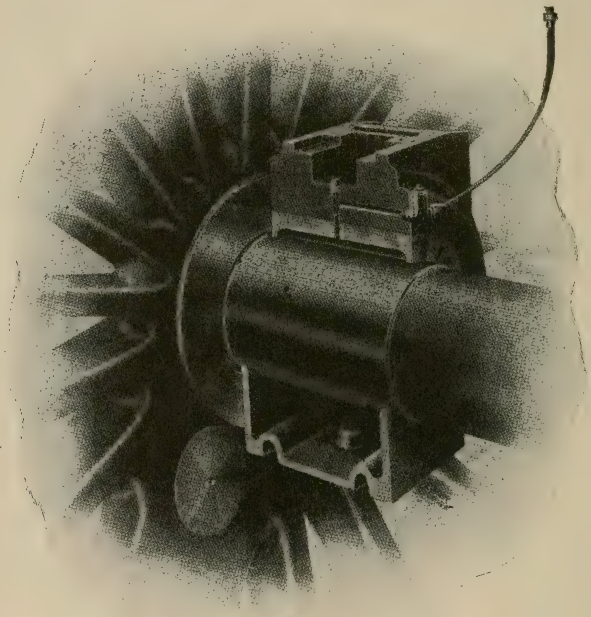


FIG. 5.

GRAPHITE LUBRICATORS.

For many years it has been known that Graphite, which was formerly more generally known as "black lead" or "plumbago," had remarkable lubricating properties, and in that connection possessed certain advantages, such as its attraction for metal surfaces, its freedom from the influences of heat and cold, and its imperviousness to the action of acids and alkalies.

In recent times it has been found that when free from grit, clay or similar impurities it fulfills to a remarkable degree the requirement of a good lubricant and that its application fills up the minute depressions, roughness and pores in metal surfaces, and, through its tendency to attach itself to metal, builds up a veneering of marvelous smoothness and great density and endurance.

Graphite, however, cannot be said to be a complete lubricant in itself. Its essential function is that of an auxiliary or accessory, which perfects and maintains the working surfaces in a condition of high polish and great smoothness, so that oils and greases used as the actual lubricating film may the more successfully and economically perform their particular service. With graphite as an auxiliary, oils and greases have only to separate two highly polished and perfectly filled surfaces, and thus reduce friction to the minimum.

AUTOMATIC FORCE FEED GRAPHITE LUBRICATOR.

The device herewith illustrated is intended for lubricating valves and cylinders with a mixture of extra fine crystalline graphite and oil. As a result the surfaces soon become coated with a thin film of graphite, reducing the friction between the parts, as compared with the use of oil, and also considerably increasing the number of miles run per pint of lubricant.

The device, or pump, which is automatic in action, is placed near the cylinder, one on each side, as shown in Fig. 1, and is operated by a connection with the valve rod. It does not require any attention on the part of the engine crew except for adjustment at the beginning of the run. Nor does it require much attention on the part of the engine house force except for the occasional replacing of a small leather washer.

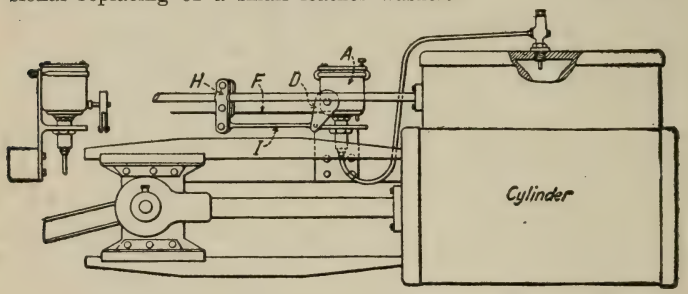


Fig. 1. Graphite Lubricator Applied to Locomotive.

One of the troubles in using graphite as a lubricant has been the difficulty of feeding it to the cylinders properly. The trouble has been to keep the graphite in suspension in oil or other fluids. In this device the accomplishment is claimed to be made by stirring or agitating the mixture continuously until it reaches the steam chest. It does this in the following manner:

The pump, which is enclosed in a brass casting A, Fig. 1, is securely fastened in place, as shown. The lubricant, to the extent of three pints, is introduced by removing the top of the casting. As indicated in Fig. 2, a fine screen is fitted in the top of the device through which the lubricant must pass. Directly underneath the screen is a circular box-shaped casting supported on two pivots. A short arm projects downward from this casting at the right; at its lower end is a toothed sector which meshes with a small pinion on the end of the shaft that extends through the casing and has a knurled nut at its outer end. By turning this nut the pivoted box casting can be set at an angle with its horizontal position, a pointer on the outside indicating the amount

of this angle. With the box in a horizontal position the stroke of the pump is zero. As the box is inclined more and more the stroke is increased. Within the box at the right is a crosshead enclosing a spherical knob which is formed on the end of a forked lever that rotates and rises, according to the inclination at which the box may be set. The forked lever is connected at the other, or left, end to a short link; to the right of this and near the middle of the lever it carries between the forks a truncated sphere,

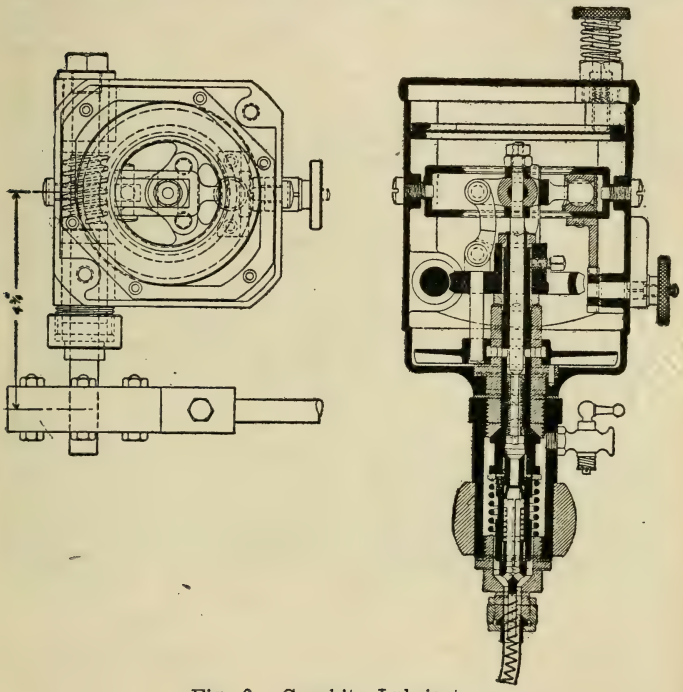


Fig. 2. Graphite Lubricator.

through which the end of the pump ram passes. The pump ram works in a rotating casing to which the worm wheel is attached that is driven by the worm. This worm is driven by the ratchet D, Fig. 1, through the connecting rod I, which is fastened to the clamp H on the valve rod.

The pump barrel works within a gland screwed into the bottom of the casing; this gland extends through the casing and carries on its upper side a short cylindrical casing. Within the main

casing this gland provides a seat for the two-vaned propeller which stirs up the graphite and oil. The short curved link, which is attached to the end of the forked lever, is pivoted from a bolt passing through the worm wheel, and extending down into a hole formed for its reception in the boss of the propeller. The rotation of the worm thus drives the worm wheel, the propeller, the link and forked lever, the pump ram and the pump barrel. In addition, the ram has a rising and falling motion due to the inclination of the guide-box.

Within the lower cylindrical casing the pump barrel, which bears against the lower surface of the fixed gland through an inclined shoulder, has screwed into it a valve casting. This casing

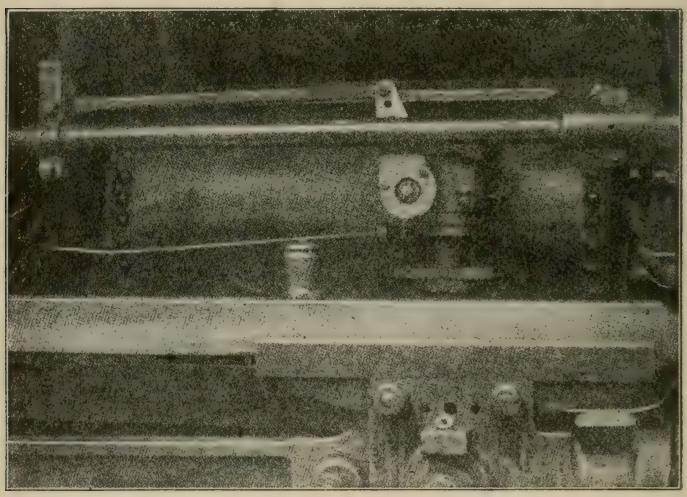


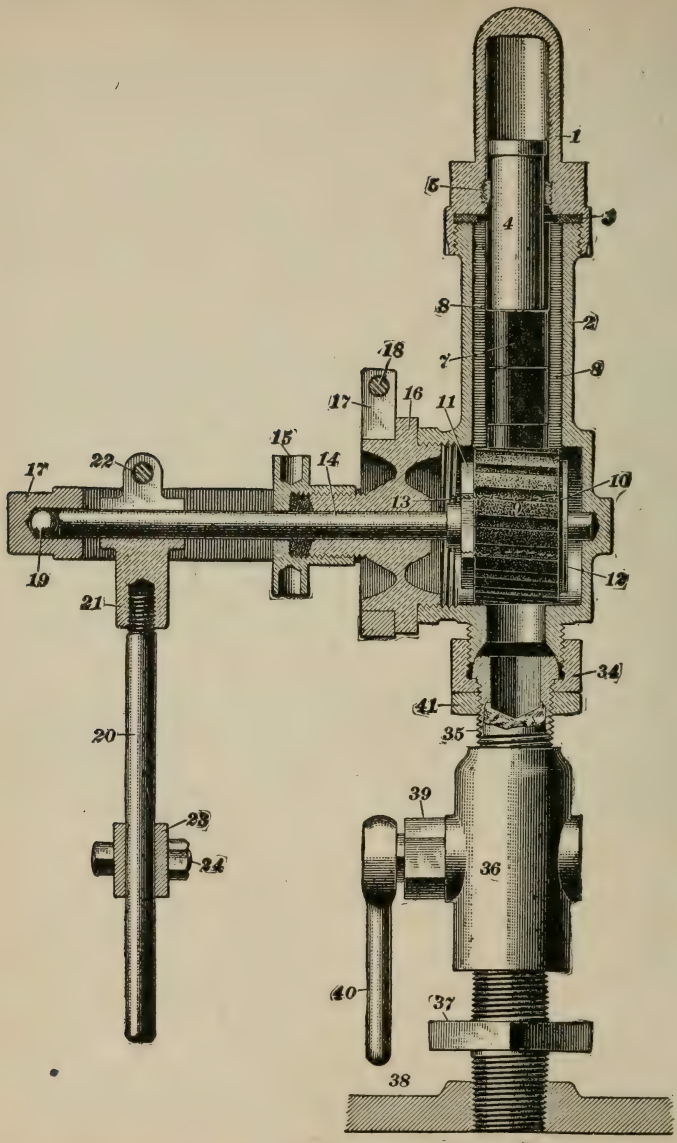
Fig. 3. Graphite Lubricator Applied to Locomotive.

is in turn closed by a nipple through which two holes lead to the delivery pipe. A non-return valve provided with a small leather washer at its upper end is held up against its seat in the valve chamber by a spring. The end of the nipple protrudes in the shape of a spigot just within the copper delivery pipe. A spiral spring extends through the delivery pipe from an extension spigot to the point of delivery into the steam chest and is rotated by its attachment to the spigot. The rotation of this spring keeps the lubricant stirred up during its entire passage through the pipe. A strong spring bears against the lower end of the pump casing and takes up wear, preventing leakage from the upper chamber.

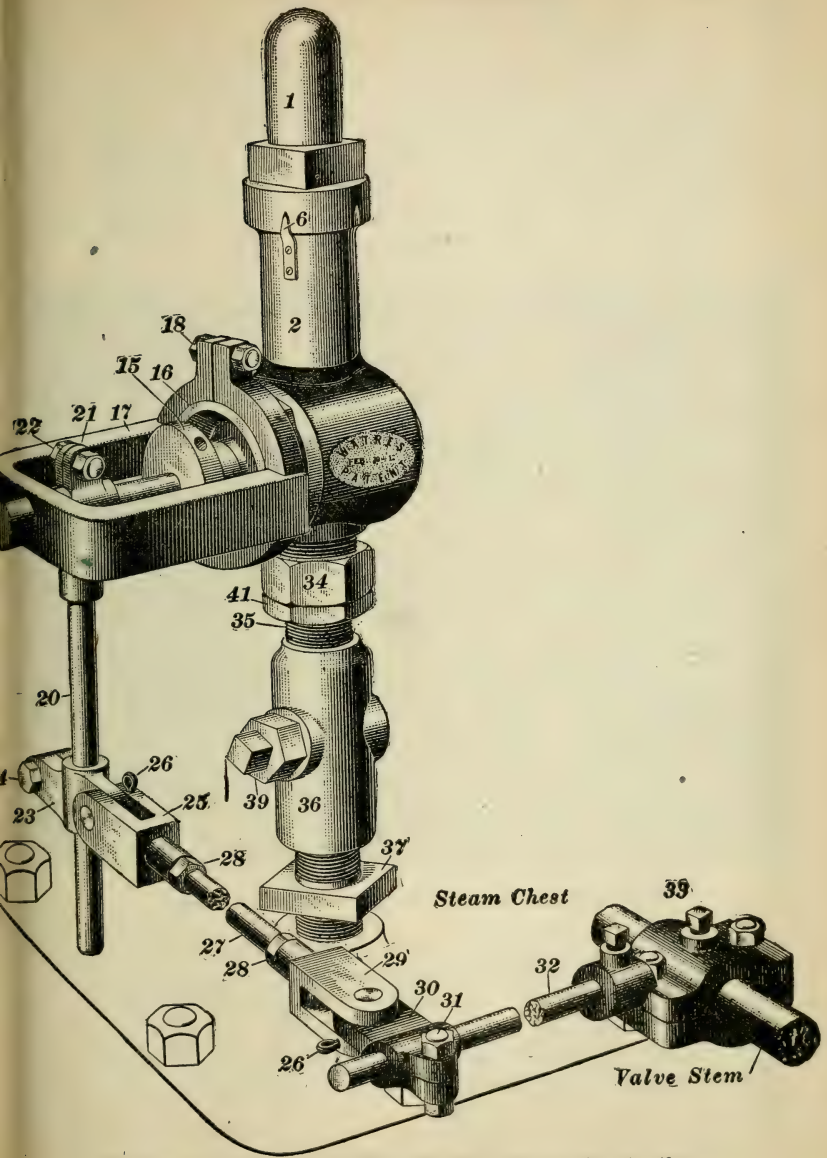
This is quite important when the jars and shocks to which the apparatus on the locomotive is subjected is considered. The lubricant finds its way from the reservoir to the interior of the pump barrel through a hole drilled in the boss of the propeller. This admits the mixture to an annular channel formed on the inner surface of the boss. Two ports in the stationary gland then conduct it to a similar channel on the inner surface of the gland, and from this passage it escapes to the interior of the barrel through two other ports drilled through its walls. In this way the lubricant has an uninterrupted access to the barrel at all periods of its revolution. A small hollow piston is carried on the reduced lower end of the ram, and is given 1-32-inch vertical play between the cone seat and a winged nut on the extreme end of the ram. During the up stroke of the ram the lubricant thus has free admission past the conical seat to the under side of the piston; on the down stroke the cone and piston close up so as to pump the mixture past the non-return valve. On the lower cylindrical chamber an air cock is provided for use when starting up.

There can be but very slight wear on the parts because they move slowly and are always flooded with the lubricant. Because of the exposure of the device, arrangements have been provided to heat it by steam during cold weather through the pipe F, Fig. 1.

Pure crystalline graphite only is suitable for cylinder lubrication. Amorphous graphite contains impurities which are difficult to eradicate and make it entirely unsuitable for the purpose. Even the crystalline graphite must be carefully refined to give successful results.



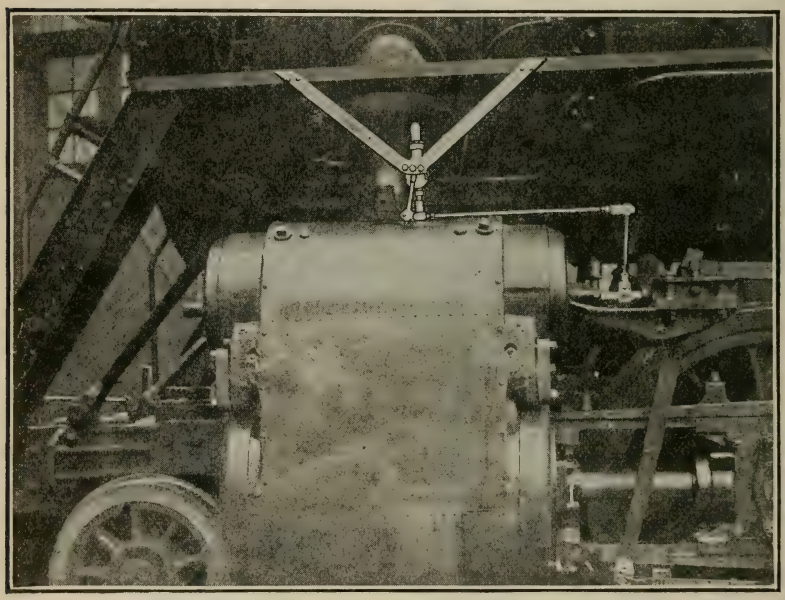
National Graphite Lubricator



National Graphite Lubricator, Showing Connection to the Valve Stem

THE NATIONAL GRAPHITE LUBRICATOR

The National graphite lubricator is attached directly to each of the steam chests of a locomotive, as shown in the first illustration, and consists of a holder for compressed cakes of graphite forced by a weight (4) against an abrasive wheel (9) which derives its motion from the valve stem, as shown in the second cut. This lubricator is applied to a locomotive



National Graphite Lubricator Showing Application

in addition to the usual oil lubricator located in the cab. It is claimed that by this means a small quantity of powdered graphite is supplied to the valves and cylinders in quantity proportionate to the speed of the locomotive. The manufacturers of this device claim a great saving of fuel as compared with oil lubrication because the graphite fills up the pores of

the metal and makes a perfectly smooth surface, and when the pores once become filled, it is difficult to dislodge these particles of graphite, even by the action of water passing through the valves and cylinders. Further than this, the graphite is not affected by high temperatures, which makes it particularly adapted for lubrication of superheater locomotives.

It is generally acknowledged that locomotives being handled at terminals receive rough treatment. For instance, they will stand on the ash pit or in the roundhouse for hours, and when it is necessary to move them, hostlers, of course, handle the engines, and there is a great amount of water worked through the valves and cylinders. Where oil lubrications only are used, this washes out the oil entirely. Where graphite is used, the water has practically no effect on the lubricant, and the engines are still lubricated when they leave the terminals.

One piece, or cake, of graphite one inch in diameter and one inch long is sufficient lubrication for from 75 to 150 miles, with the addition of a small quantity of oil from the oil lubricator in the cab.

CAMPBELL GRAPHITE LUBRICATOR

The value of graphite for auxiliary lubrication of locomotives is too well known to need explanation. A satisfactory

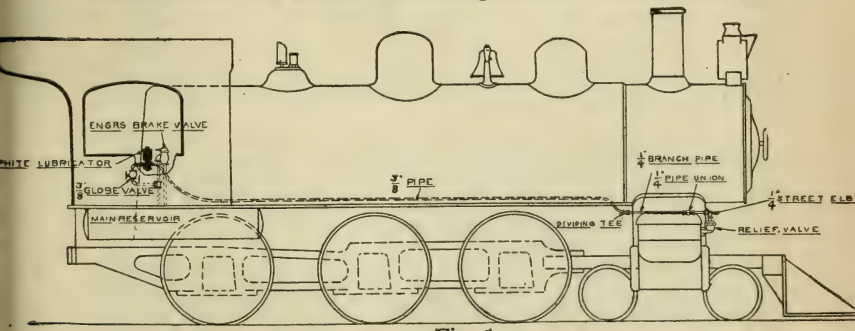


Fig. 1

means for depositing graphite into the valves and cylinders is provided by the Campbell system for the injection of dry graphite by means of air, which is a positive method as it has been demonstrated that it cannot be properly distributed when mixed with oil. A small amount will give instant relief to a badly working engine as reports show that with the use of the graphite lubricator the most troublesome engines have been quickly restored to full working capacity due to the graphite smoothing over the frictional surfaces of the valves, valve

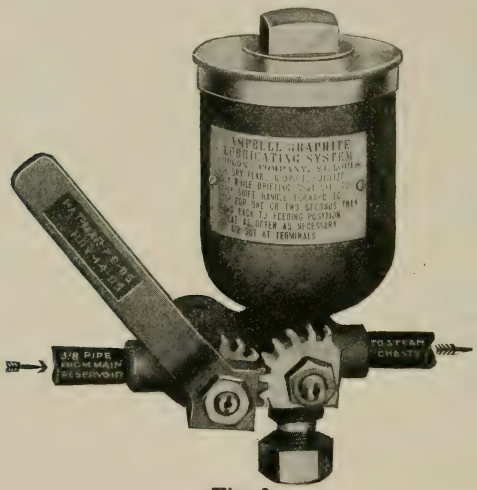


Fig. 2

chambers, cylinders and pistons, thereby minimizing frictional resistance.

This lubricator is not a complicated machine requiring an expert to keep it in operating condition. It cannot get out of order and there are no maintenance charges. It is only necessary to keep dry flake graphite in the cup and use the lever handle when necessary.

A cup holding about one pound of graphite is placed in the locomotive cab, convenient to the engineer, and is connected up by means of a ⅜-inch pipe with the main reservoir.

Another ⅜-inch pipe extends from this cup to a special dividing tee to be located directly back of the center of the cylinder saddle, from which ¼-inch pipes extend, and are tapped into each relief valve. In case the locomotive is not equipped with relief valves, tap the oil plug into the top of each chest and connect the ¼-inch pipes, putting a check valve as near to the oil plug as possible in order to avoid back pressure. With the lever handle in running position a charge of about one-half teaspoonful of dry graphite is projected to the valves by shifting the handle from running to charging (or application) position and on return of the handle to running position, another application can be made immediately, if desired.

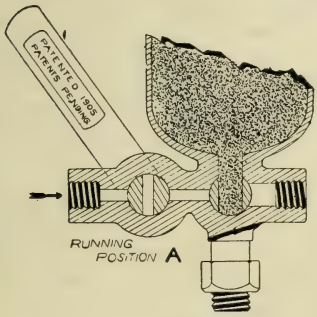


Fig. 3

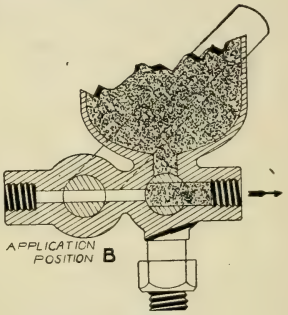


Fig. 4

When valves become dry from the engine raising water suddenly or from any other of several causes familiar to locomotive engineers, shut off the throttle and give two or three applications of dry graphite, when the result will be immediate.

When beginning the use of this graphite lubricator, make three or four applications every 30 miles for a period of ten days. After several trips the wearing surfaces will be well glazed, when one application every forty to fifty miles should suffice to keep the valves and cylinders in smooth condition, and enable the engineer to handle the reverse lever with about half the usual effort and with half the usual consumption of valve oil.

FRANKLIN DRIVING BOX LUBRICATOR

The Franklin driving box lubricator automatically lubricates locomotive driving journals with grease, thus eliminating hot driving boxes. It consists of the following parts, as shown in Fig. 1: cast iron cellar; end plate, which covers the entire inside end of the cellar; perforated plate and follower plate. For switching service the perforated plate has perforations ⅜ inch in diameter; for regular road service $\frac{3}{16}$ inch perforations are used. No. 1 rod cup grease is used for switch and driving journal compound for road service. The follower plate has two indicators and a spring fastened to it. The indicators protrude through the bottom of the cellar and show the amount of grease in the lubricator. A spring is used to support a cake of grease and hold the grease and the perforated plate in contact with the journal. The cellar is made of vanadium cast iron and by a special process which insures the interior being perfectly smooth. These parts are shown clearly in the accompanying illustration (Fig. 1).

When applying the lubricator particular attention should be given to the grooving of the journal brass as shown in Fig. 2. The cut shows the practice as recommended by the manufacturers:—both sides of the brass should be relieved ⅜ inch above the center of the journal on main boxes and 1 inch on all others, unless the journals are very small, in which case they should be relieved sufficiently to allow the grease to feed freely to the bearing. If the bottom edges of the brass are not relieved they will scrape the grease from the journal and prevent the lubricant from reaching the bearing. Grooves ¾ inch by ½ inch deep should be cut on each side of the brass to act as reservoirs to collect a supply of grease. These grooves should not be cut through the ends of the brass, as the grease would then feed out rapidly. On the back side of the journal only, two ⅜-inch by ⅜-inch grooves should be cut from the bottom of the brass to the reservoir groove to assist in feeding the grease. The reservoir grooves on either side of the brass should be connected with ⅜-inch by ⅜-inch grooves cut diagonally across the bearing, like the letter X. If babbitt strips are applied the grooves should not extend

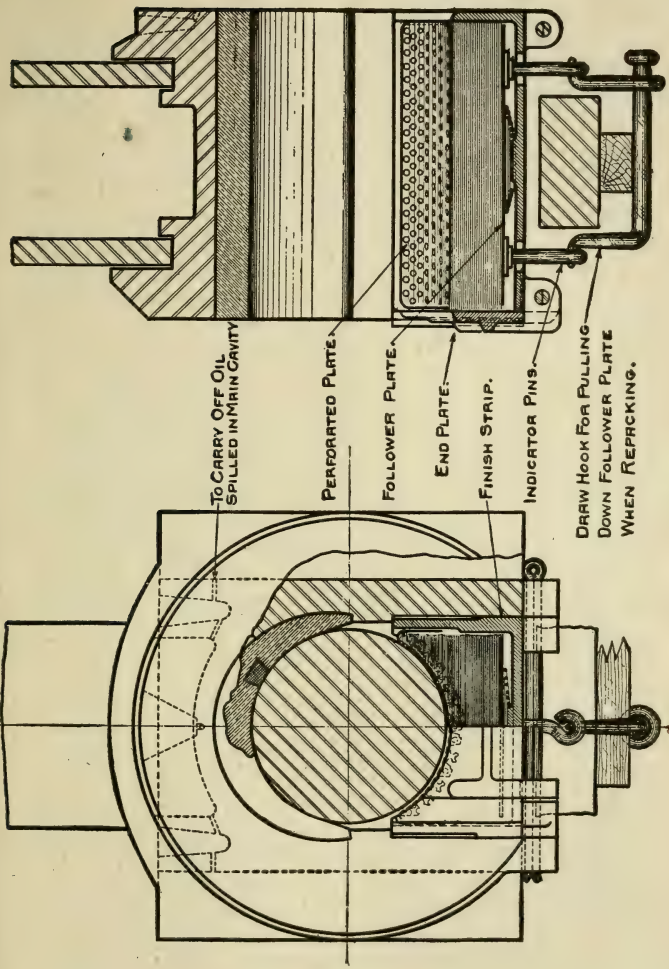


Fig. 1
Franklin Automatic Driving Box Lubricator

through the ends of the brass, but should be confined so that in case the bearing heats the expansion of the babbitt will be out against the journal, relieving the bearing and thus allowing a good coating of the lubricant to distribute itself over the bearing. Many railroads find better results by using no babbitt in driving boxes lubricated by grease.

All the oil holes leading from the oil cavity in the top of the box to the journal should be plugged. If this is not done the grease will feed out through them in a very short time. When plugging the oil holes in old boxes the plug should be screwed in or a taper plug used, the larger end of the taper being on the inside of the brass, so that it will not be forced out. On new boxes when grease is used the oil holes should not be drilled. Holes should be drilled from the main cavity to shoe and wedge faces of the box to carry off any oil spilled in the cavity when the shoes and wedges are being oiled.

When the lubricator is applied the perforated plate should be fitted so as to have a bearing on the journal over its entire area and should fit so as to move freely in the cellar. Before the box is applied to the journal the groove in the brass should be filled with grease and a thin coating put over top of the perforated plate to insure lubrication when the engine starts out. When packing the cellar the grease cake should be made to fit the perforated plate. The plate should not be bent to fit the grease, but the grease shaped down until it meets the size and contour of the plate.

The running temperature of the journal when grease lubrication is used will be higher than with oil. This, however, should cause no alarm and the lubricator should not be disturbed so long as the indicator shows there is plenty of grease in the cellar and there is no external evidence of trouble. The driving boxes, shoes, wedges and lubricators should be inspected after each trip, particular attention being paid to the following: that the brass is not loose in the box or tight on the journal; that the shoes and wedges are not dry, neither should they be tight or loose; that there is sufficient grease in the cellar; that the perforated plate is in contact with the journal; that the end plate is securely fastened; that no water is running into the cellar or over the hub, shoe and wedge

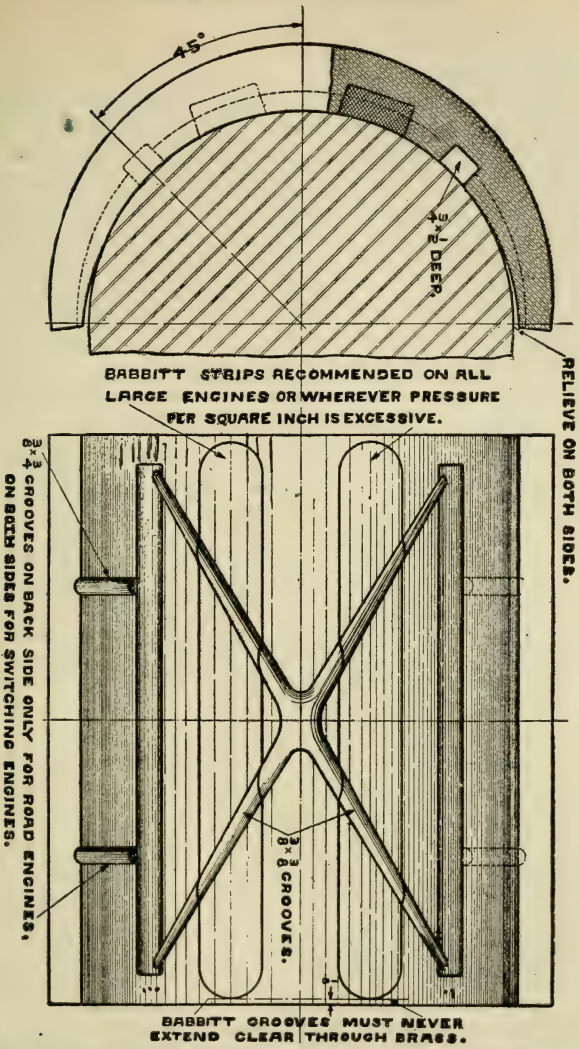

45°
3/4 × 1 DEEP.
BABBITT STRIPS RECOMMENDED ON ALL LARGE ENGINES OR WHEREVER PRESSURE PER SQUARE INCH IS EXCESSIVE.
RELIEVE ON BOTH SIDES.
3/8 × 3/4 GROOVES ON BACK SIDE ONLY FOR ROAD ENGINES. ON BOTH SIDES FOR SWITCHING ENGINES.
3/8 × 3/8 GROOVES.
BABBITT GROOVES MUST NEVER EXTEND CLEAR THROUGH BRASS.

Fig. 2—Franklin Driving Box Lubricator—Showing Journal Clearance and Brass Grooving Recommended.

faces, as water tends to liquify the grease, causing it to run out of the cellar.

When re-packing the lubricator the perforated plate and follower plate should be cleaned in a lye vat or with live steam. The plates should never be cleaned with fire. The cake of grease should be made to fit freely in the cellar, care being taken in fitting it to the perforated plate to see that the plate is not distorted. Grease should not be packed directly in the cellar with hammer handles, bolts, etc., as this will cause the cake of grease to stick in the cellar, preventing the follower plate from holding it up in contact with the journal. Grease removed from the cellars must be carefully cleaned and if apparently in good condition, can be used again, first removing the top crust. The supply of grease must be kept clean and protected from moisture.

The lubricator is not intended to lubricate anything but the journal. The hub, shoes and wedges should be oiled in the usual manner.

If any external conditions exist such as grease working up over the end plate, or being scraped off at the bottom of the brass, brasses cutting, or extremely high temperature, immediately after arrival the perforated plate should be cleaned and the cellar re-packed; and if the brass has been cut, jack the box up enough to raise the brass off the journal and use hose with hot water or steam in order to remove brass cuttings from around the faces of the journal and hub. Before doing this the cellars should be removed and, after cleaning, the box given a chance to drip before it is re-applied. This is only necessary in extreme cases. Wedges should be adjusted when the engine is warmed up. The main wedge should be put up tight and then pulled back about $\frac{3}{16}$ inch for cast iron boxes; $\frac{1}{4}$ inch for steel boxes. Other wedges can be pulled down $\frac{1}{4}$ inch to $\frac{3}{8}$ inch as no pound will result. When adjustment of wedges is made the engines should be on a straight track and up against the shoe in order to take up the lost motion. Wedges of boxes lubricated with grease should not be as snug as when lubricated with oil.

If the journal should run warm and it is found that the indicators show unequal height, it denotes that the follower

plate is cocked in the cellar. In this case the lubricator should be removed and inspection made to ascertain if the perforated plate has proper fit on the journal. This can be determined by the lustre of the plate where it has touched the journal. If it does not have full bearing, it should be refitted. If the perforated plate shows carbonization or burnt grease it should be cleaned and the lubricator re-packed. When the temperature of the box has been sufficient to melt the grease it frequently runs between the walls of the cellar and the follower plate, forming a wedge sufficient to prevent the tension of the spring from feeding the grease. The condition of the grease should be tested before applying to the lubricator. This is done by working a small piece with the fingers until soft. If it cleans off and does not cling to the fingers, the grease is all right; if it sticks and pulls off in a stringy mass, it can be considered doubtful. Should a box run hot on the road, if there is a supply of grease in the cellar it will take care of the box until the engine reaches its destination.

When removing the lubricator a bar should never be used between the journal and the end of the cellar. Should the cellar stick in the box, hooks may be inserted in the lugs on the bottom of the cellar as a "puller," and a bar used on top of a chain which connects the bottom of the hooks. With this method the cellar can be removed without marring the journal.

WHEEL FLANGE LUBRICATORS

There is a continual wear on the flanges of a locomotive wheel, and consequently a wear on the rails due to the friction between the wheels and rails.

The Collins Wheel Flange Lubricator herein illustrated is intended to reduce this wear by keeping the flange continually covered with a lubricant.

Fig. 1 shows this device attached to a bracket on the front driver of an engine. It may also be attached directly to the locomotive frame as required.

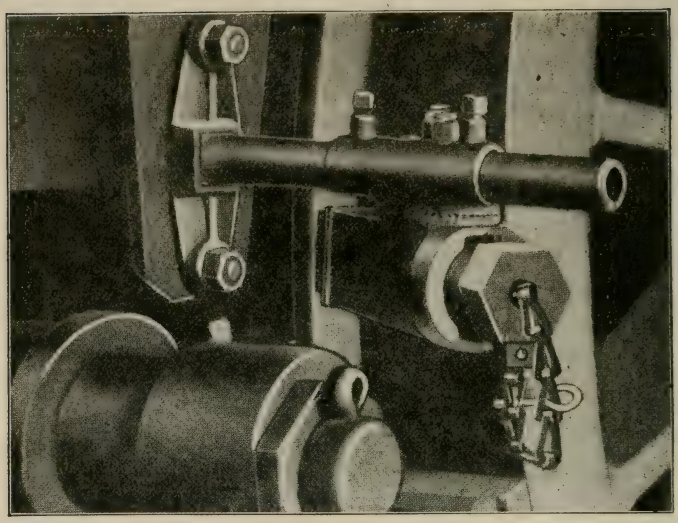


Fig. 1. Lubricator Attached to Bracket on Front Driver of Engine.

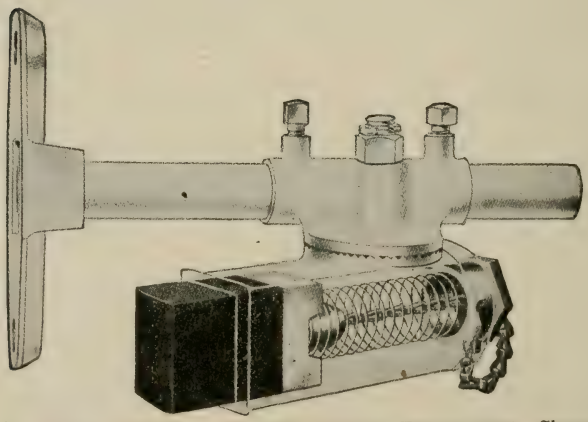


Fig. 2. Body Shown as Though It were Transparent, Showing Continuous Feed Device.

The device is made entirely automatic by the use of a continuous feed, Fig. 2. Fig. 3 shows the way to insert a new lubricating stick, which is a solid.

The manufacturers claim that this device does not interfere with the tractive power of the engine, as the lubricant is applied only to the flange and does not fly off. There is very little wear of the lubricating stick impinging on the already lubricated surface of the flange, as the coating remains intact

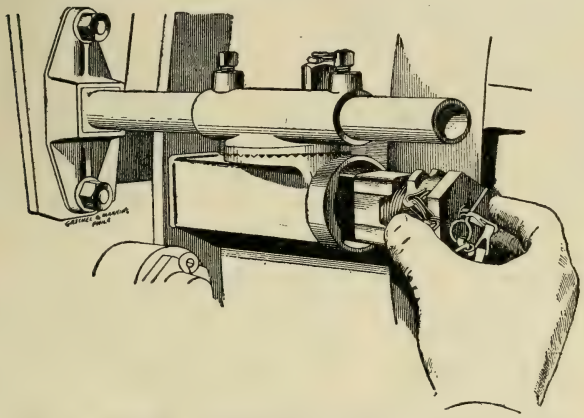


Fig. 3. Method of Inserting a New Lubricating Stick.

except when it is displaced by the flange coming in contact with the rail. The life of the stick varies with the number and degree of curves on the road. Some sticks having been in service from 3,000 to 6,000 miles. The chain indicates clearly the amount of the stick which is used. Inserting a new stick, which takes less than a minute's time, is the only attention required.

Fig. 4 shows the different parts of the lubricator.

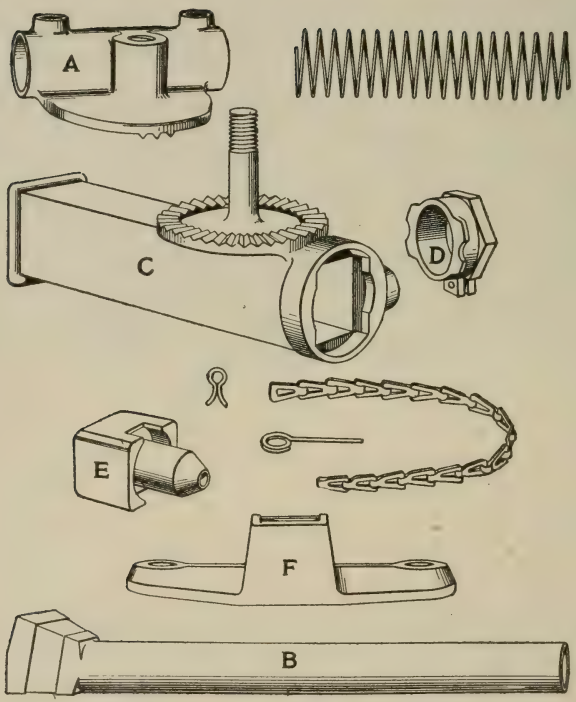
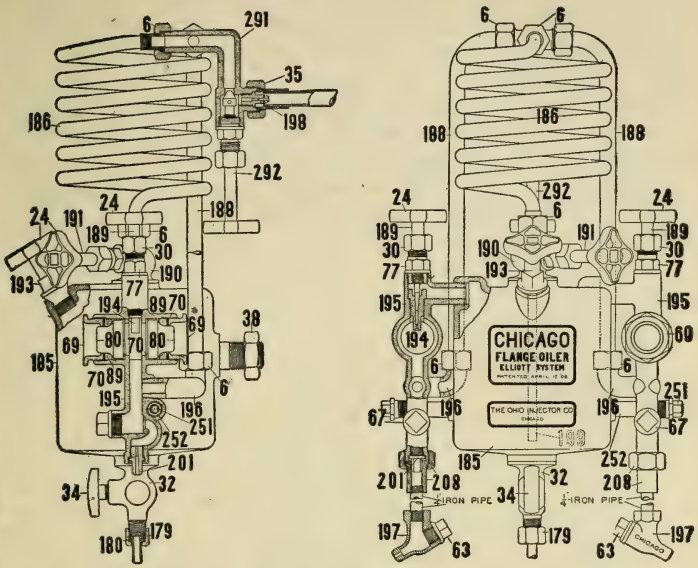


Fig. 4. Wheel Flange Lubricator Dissembled.

CHICAGO FLANGE OILER



34—Drain valve for oil bowl.
35—Steam Connection.
69—Packing nut for glass.
70—Follower ring and washer for glasses.
80—Solid glass for sight feeds.
89—Gaskets for solid glasses.
189—Feed valve.
191—Condenser valve.
193—Filler plug.
194—Feed tips.
197—Flange nozzle.
198—Steam pipe choke.
201—Choke for oil delivery pipe.
207—Oil delivery valve.

1st. Open steam full at boiler. Open condenser valve 191 three turns, then regulate feed of oil with feed valve 189.

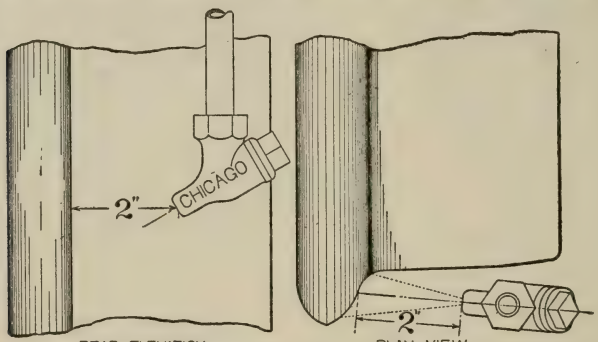
2nd. The Oil Delivery Valves 207 under the sight feeds should be left side open at all times except when being used

to blow out the Oiler or Oil Delivery Pipes. They should not be closed when the Oiler is shut off.

3rd. By closing either one of these valves full steam pressure can be turned into the opposite pipe to blow it out. By closing both valves and condenser valve and opening the drain valve and then opening the feed valves one at a time the feed tips and reservoir can be blown out.

4th. The Oil should be fed at the rate of 15 drops per minute, or faster if the engine requires it, until the condition of the track and flanges will warrant a reduction of this rate.

5th. When starting, turn on the Oiler main steam valve at the fountain, fifteen minutes before the feed valves No. 189



APPLICATION OF FLANGE NOZZLES TO DRIVING WHEELS

are opened; and when shutting off the oiler close the feed valves No. 189 fifteen minutes before the main steam valve is closed. This permits the steam to clean the pipes and prevents clogging of the nozzles. If the oil is allowed to remain in the pipes during cold weather, it will harden and prevent circulation.

6th. To clean flange nozzle 197, remove cap 63, and run wire through opening. Then turn on steam and blow out pipes. There should be the same flow of steam through each nozzle at all times.

7th. Use only asphaltum oil in this lubricator. If valve oil, engine oil or grease is used, it is likely to cause the wheels to slip.

ENGINE TRUCK OIL CELLAR AND SIGHT-FEED OIL CUP.

The "Acme" combined cellar and oil cup is designed especially for engine trucks to overcome the friction, journal wear, and that bane of the railroad man's existence, hot boxes, and thereby

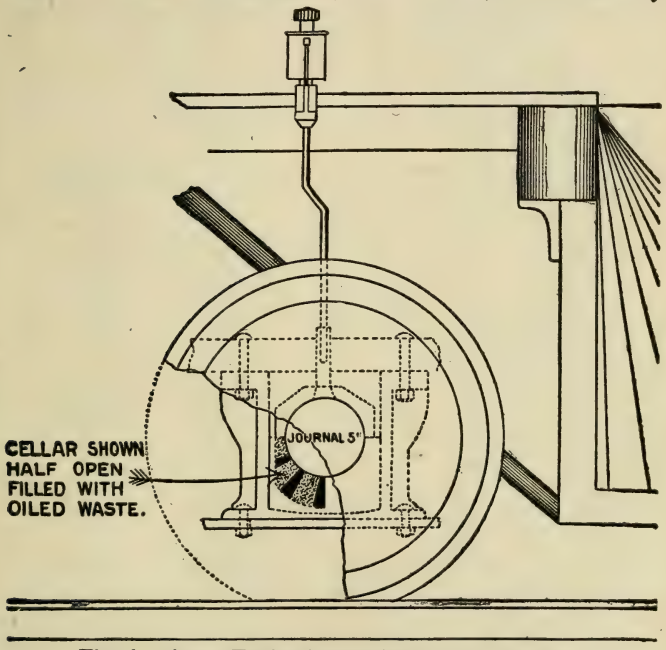


Fig. 1. Acme Engine Truck Cellar and Oil Cup.

to prevent unnecessary stopping of fast trains and to permit of long distance runs between stopping points. By giving a regular feed of oil to the bearings it is claimed to effect considerable saving of oil.

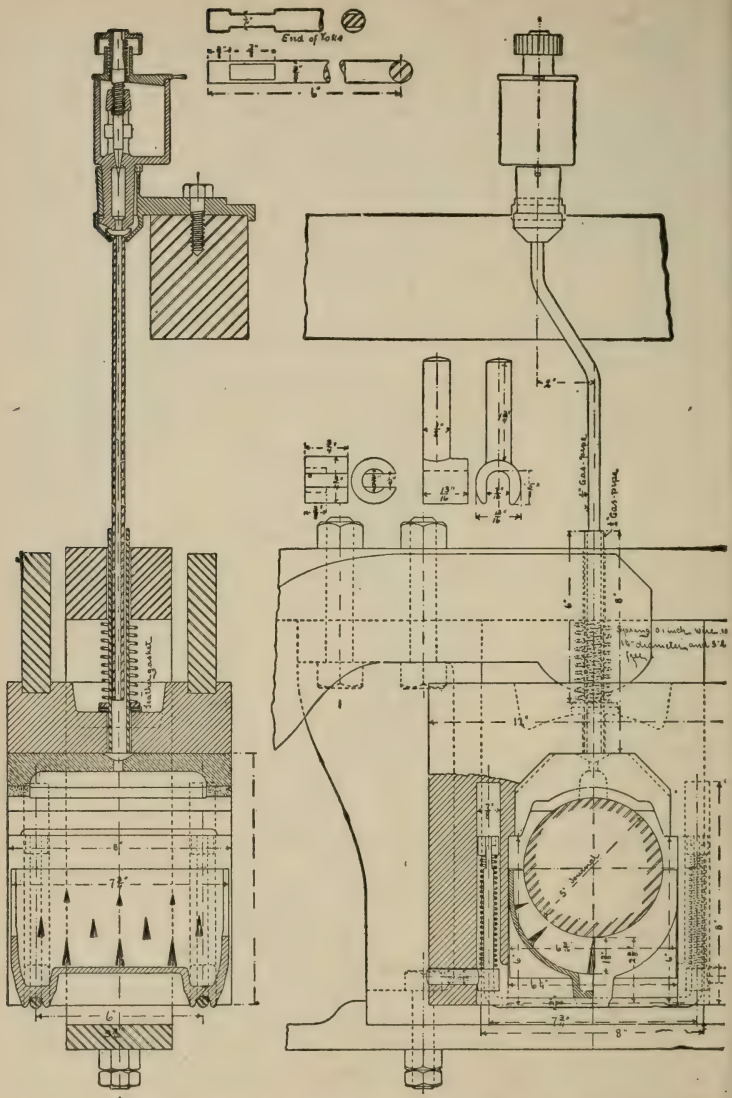


Fig. 2. Acme Automatic Engine Truck Cellar with Acme Sight-Feed Cup.

Fig. 1 gives a general view of these devices as applied to the leading wheel of an engine truck; Fig. 2 shows the details of both the cellar and the oil cup.

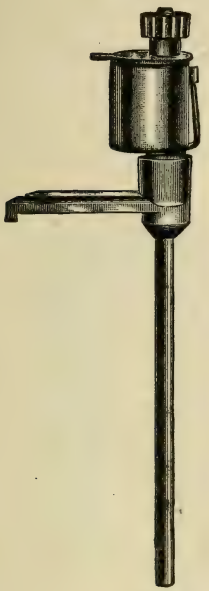


FIG. 3.
Acme Oil Cup.

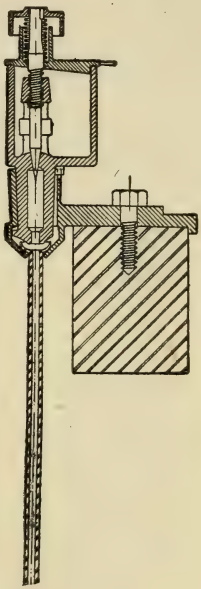


FIG. 4.
Acme Oil Cup.
(Sectional View.)

From the latter engraving it will be noted that no cellar-bolts are required, and hence none can be lost, as frequently occurs on the road with the ordinary form, but that the cellar is held up to the journal by four coil springs. By this arrangement the cellar may be pulled down and removed instantly without a

wrench, and, yet cannot be lost from the truck box when replaced.

Fig. 3 shows the oil cup and supply pipe. When in place, the bottom end of the pipe is connected to the engine truck by a short piece of rubber hose.

Fig. 4 is a sectional view, from which the internal arrangement of the cup is seen to be that of a "needle feed" oil cup adjustable from without. The cup is detachable by simply turning it half around and lifting it out when necessary to clean, but its shape prevents its being jarred out and lost while the locomotive is running.

OIL CUPS.

There is no more important requisite for the proper running of a locomotive than adequate provision for the proper lubrication of those parts wherein it is necessary to overcome the deterrent effects of friction.

One of the devices for accomplishing this is the oil cup, the aim of which is to continually supply

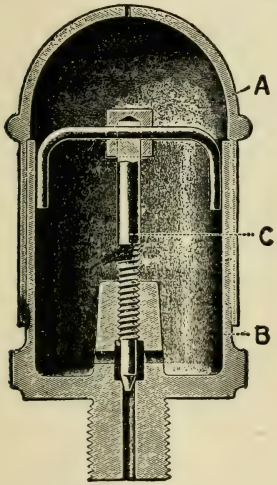


FIG. 1.
Guide Cup.

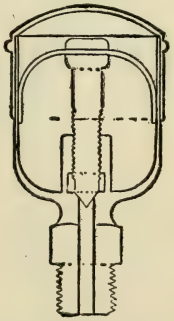


FIG. 2.
Guide Cup.

the bearing with lubricant while in motion, to feed little or no oil when standing still, and to feed copiously when the bearing gets hot.* There are so many

*The subject of lubrication and lubricants is referred to in another volume of "The Science of Railways."

different kinds of oil cups in use, many of them patented, that it would be impossible to describe them all. The following examples will, however, serve in a general way to indicate the various types and the uses to which they are put:

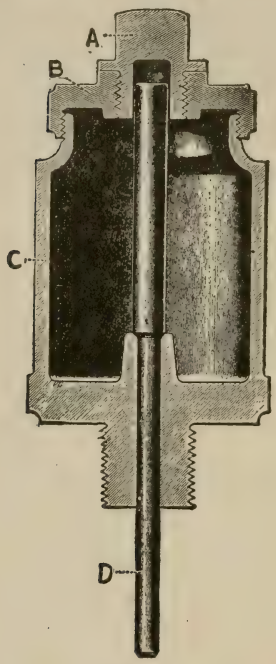


FIG. 3.
Spindle Feed Rod Cup.

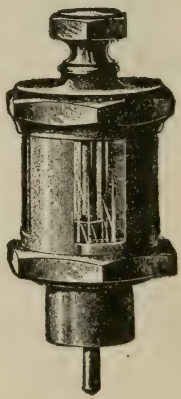


FIG. 4.
Locomotive Bearing Cup for Connecting Rods.

Guide cups are used to lubricate the guides (see plate "American Type Locomotive," parts numbered 89), and Figs. 1 and 2 illustrate a common type used for this purpose.

A is the cap or cover, *B* the body and *C* the adjust-

able feeder (Fig. 1). By turning the screw feed to the left the needle feed is opened to any extent desired, and by turning to the right it may be entirely closed, as, for instance, when the engine is not running.

Spindle feed cups are used on revolving parts. An example is shown in Figs. 3 and 4. These cups can be filled through the hole in the top without dis-

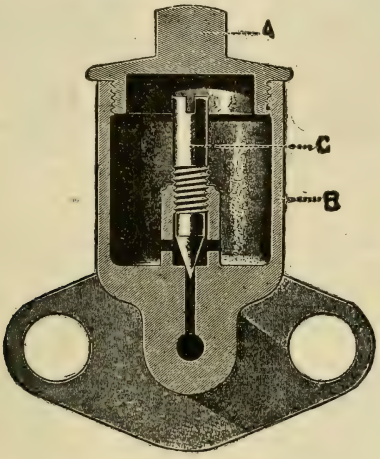


FIG. 5.
Oil Cup for Front End Main Rod on Cross Head.

turbing the regulating device, and will not feed except when the engine is in motion.

The spindle *D*, Fig. 3, is thrown up and down again with each revolution of the pin, and a small amount of oil is churned down to the bearing. As the bottom end of the spindle *D* is on or near the bearing, any heat in the latter is quickly carried up the spindle, thereby causing a greater flow of oil downwards to the pin or bearing.

Fig. 5 shows a needle-feed oil cup for the front

end of main rod on the cross-head. (See plate "American Type Locomotive," part numbered 96). By removing the cap the needle may be raised to regulate the amount of feed.

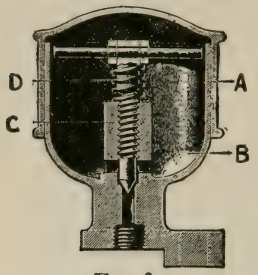


FIG. 6.
Valve Stem Oil Cup.

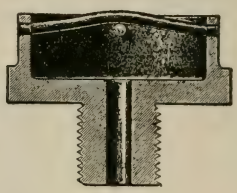


Fig. 7.
Main Rod Front End, Oil Cup.

Fig. 6 shows an adjustable needle-feed cup sometimes used on valve stems, although an open cup similar to Fig. 9 with a pipe from the bottom to a swab on the valve stem is perhaps more often used.

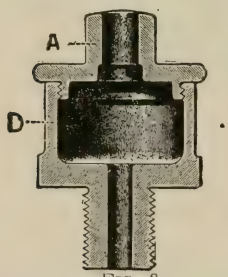


FIG. 8.
Oil Cup for Rocker Box on Cross Head.

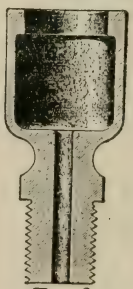


FIG. 9.
Oil Cup for Link Hanger.

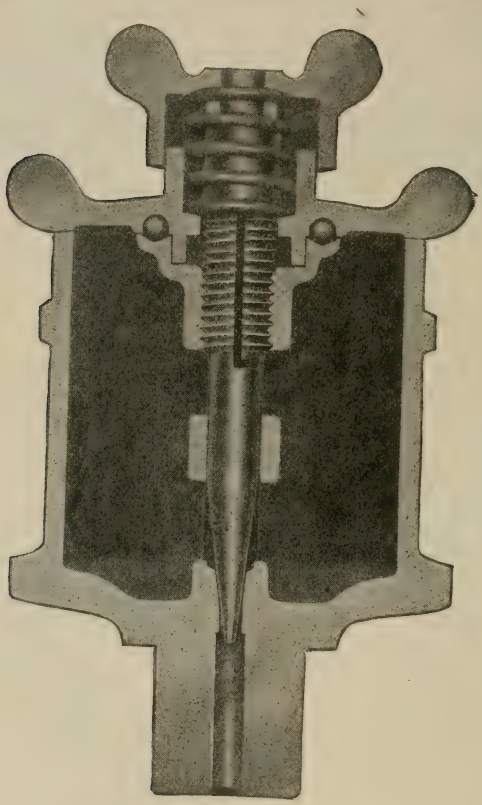
Open cups.—Fig. 7 shows a style of open cup sometimes used on the front ends of main rods, although needle-feed cups similar to Fig. 5 are in more general use for this purpose. When an open

cup like Fig. 7 is used it is filled with waste, hair or wicking to hold the oil and prevent its being thrown out of the cup.

Figs. 8 and 9 show two styles of open cups which serve as reservoirs for oil for other locomotive bearings. These cups may be packed with waste or hair to longer retain the oil.

THE HANCOCK OIL CUP

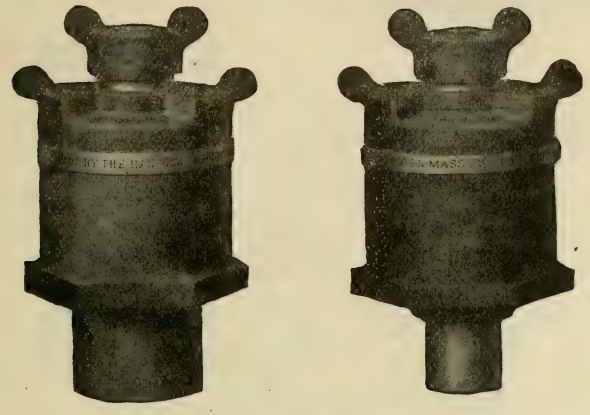
The oil cup illustrated herewith has proven very satisfactory for guides and valve stems; also for rods when grease is not employed for rod lubrication. The cover is held in



Hancock Oil Cup

place by the spring under the thumb nut of the regulating stem. When the cover is revolved a quarter of a turn it uncovers two openings through which the cup can be filled.

When the cover is opened it is lifted from its seats by means of two steel balls which are fastened securely in the cover and fit in the body of the cup; these balls hold the cover in place when closed. The lifting of the cover from its seat, when it is revolved, prevents any accumulated dirt from being wiped off into the openings in the cup.



Hancock Oil Cups

The threaded portion of the steel stem is split and is opened to provide sufficient tension to hold it in adjustment. The tension can be increased if desired as the thread wears.

These oil cups are very popular in that there are no parts to be removed for filling or adjusting, for their durability and reliability of adjustment, also for their economy in the use of oil.

GREASE CUPS.

While grease has been very successfully used as a lubricant on shop and mill machinery, its use

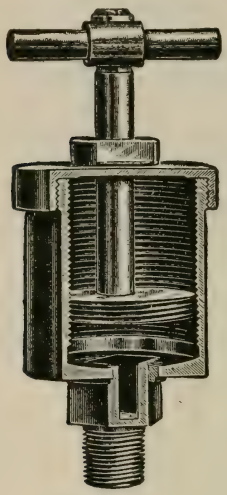


FIG. 10.
Grease Cup for Rods.

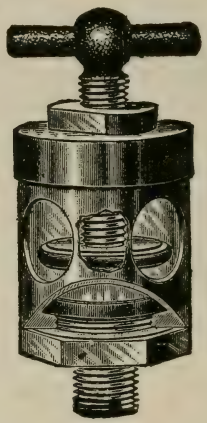
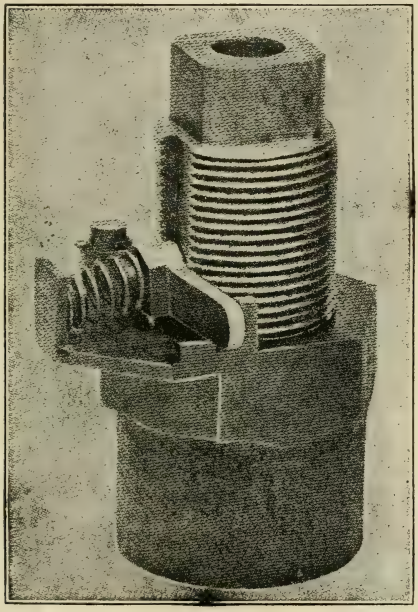


FIG. 11.
Glass Grease Cup for Rods.

on locomotive bearings has never been extensive. However, those railroads that have adopted the use of grease on main and side rods of very heavy locomotives are very pronounced in its favor from an economical, as well as a beneficial, standpoint, and give the following as an excellent formula: One box of concentrated lye in one quart of warm water, and let stand over night. Mix thoroughly by warming eight pounds of tallow and two pints of good valve oil; then add the lye and water, and stir until it becomes thick. In winter it is best to use one pound less of tallow and three pints of valve oil.

LOCKED GREASE PLUG

Where the screw plug type of grease plug is used—and this form seems to be a favorite for all rods on a number of roads —difficulty has been found in obtaining a suitable form of locking device which will prevent the screw from backing out and not only removing the pressure from the top of the grease, but also dropping out and being lost. A form of



Grease Plug Fitted with a Locking Device

plug which includes a locking device that will prevent this trouble is shown in the illustration. It consists of a brass body threaded on the bottom and screwed into the rod, and a wrought or cast iron hollow plug with a squared top and

either a flat or hollow lower end. A suitable hinged or pivoted pawl is provided and is held in place by a small coil spring. The iron plug is slotted on the side from the top of the threads to within ½ inch of the bottom of the plug, and the pawl is arranged with a lip which engages this slot when it is in the locked position. It will be seen that there is a small shoulder on the body back of the pawl. This is provided to allow the pawl to be held in an unlocked position when the plug is being removed. When locked there is no means by which the screw can back out, although it can be turned down without disengaging the pawl or giving any attention to this part.

HAND OILERS.

While there are a great many different varieties of hand oilers in use on the various railroads, their construction and operation are quite similar, and it will suffice to illustrate two of them.

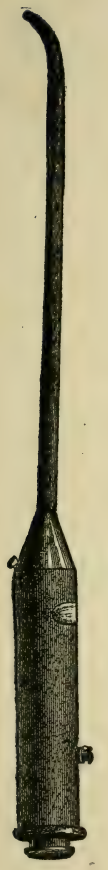


FIG. 1.
Crosby Hand Oiler.

The objection to the plain oiler having no valves is that oil is wasted while the engineer is getting the snout of the can to the oil cup or bearing, and also after it is removed therefrom until the can is tipped right side up again.

The closer the valve is located to the end of the "snout" of the can (as shown in Fig. 2) the less will be the loss of oil.

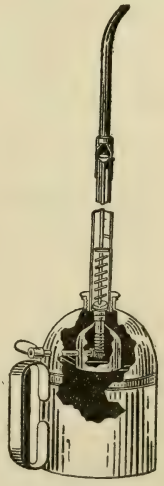


FIG. 2.
McVicar Hand Oiler.

THE LOCOMOTIVE BELL RINGER.

On locomotives traversing thickly settled portions of the country, and those engaged in suburban and switching service, running long distances within the limits of cities, mechanical bell ringers are no longer a novel luxury—they are a judicious investment of capital. Railways using them extensively or adopting them as a standard for all locomotives would as soon think of discarding the injector and going back to the old feed pump as they would of doing away with the bell ringer.

The duties of the locomotive fireman, who used to ring the bell, have increased with the increased size and speed of locomotives and the rules governing the avoidance of black smoke, because of its being classed as a nuisance about cities, if for no more economical reasons. A man furnishing coal to a ten-foot firebox developing from five hundred to fifteen hundred horse-power, has little time to do much else when the locomotive is in motion—the time when it is necessary to ring the bell.

THE VILOCO BELL RINGER
(IMPROVED GOLLMAR)

This bell ringer is preferably so arranged as to automatically start the bell ringing whenever the locomotive whistle is sounded. This arrangement is clearly shown in Fig. 1. Thus connected, it is claimed to afford valuable evidence in case of grade-crossing accidents. A small chain connected to the whistle

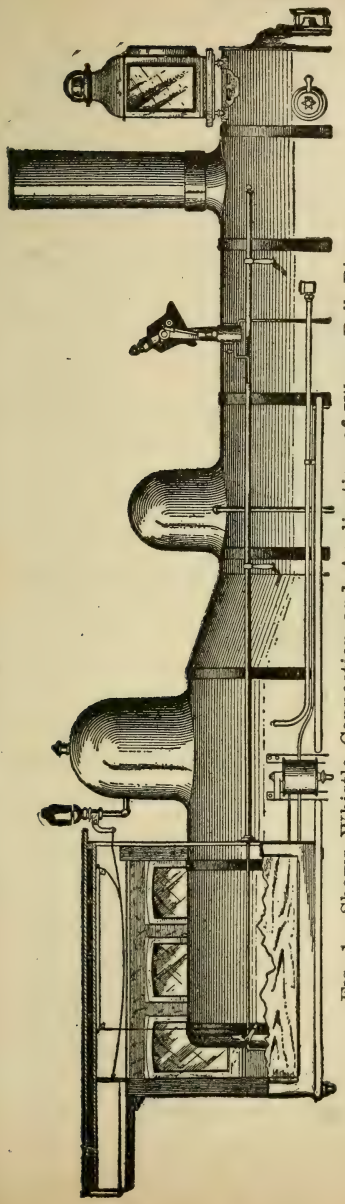


FIG. 1. Shows Whistle Connection and Application of Viloco Bell Ringer.

rigging automatically opens a small valve in the cab, which valve admits steam or air pressure to the bell ringer. This cab-operating valve is close to the engineer's hand, and may readily be opened without pulling the whistle cord.

While steam pressure may be used to operate this and other bell ringers, air pressure is much preferable, especially in cold climates.

The construction and its action are as follows, as may be seen by reference to Fig. 3: There are two openings near the bottom for pipes; the upper one is the inlet, the lower is the exhaust. Pressure is admitted through the upper opening, opposite an annular groove in valve 18, through which four holes are drilled,

admitting the pressure under the single acting piston 10; this causes piston 10 to rise, forcing the bell to swing. Piston 10 has a stroke of one and one-fourth inches when at its extreme travel; crank 2 has a stroke of four inches. The connecting rod is in two sections, 6 and 7, which allows the crank 2 to make a complete revolution without causing piston

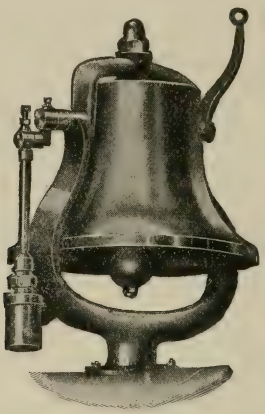


FIG. 2.
Full View of Bell Ringer.

10 to follow. When the ringer is started to work, and the pressure is admitted through the inlet port, piston 10 will be driven upward, causing the bell to swing, and valve stem 17 will raise valve 18, closing inlet port. The pressure admitted before the inlet port was closed by valve 18 expands moving piston 10 and valve 18 upward until the lower edge of valve 18 will open the exhaust port. The bell, having received an impulse, will continue its motion after the piston 10 has reached the upper end of its stroke, the crank box 6 sliding on rod 7. The impetus which the bell receives being expended, it will

fall; the governor bolt 4 will strike the end of rod 7, and piston 10 will be forced downward (being open to the exhaust below), coming in direct contact with valve 18, thereby closing exhaust port and opening inlet port after cushioning on the pressure remaining under piston 10 subsequent to the closing of the exhaust on account of the exhaust port being placed slightly above the bottom of the cylinder. It will be seen that valve 18 is only operated at the terminations of the piston 10 stroke. Packing rings 15 on the piston and on the main valve are packing rings standard to the Westinghouse eight-inch air pump reversing valve. As the rings are kept in stock by all railroads using air-brakes, no extra supply need be carried by them.

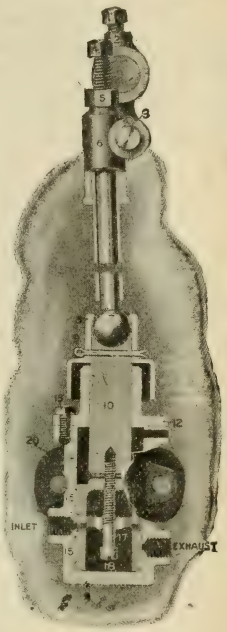


Fig. 3
Viloco Bell Ringer
(Sectional View)

The bell ringer can be easily adjusted to use pressure in proportion to the power required. This is accomplished by means of valve stem 17, which is secured in its adjusted position by a ⅛-inch pin 20. No change in length of connecting rod is required in making this adjustment. These bell ringers have been used successfully when cutting off pressure after the piston has moved but three-eighths of an inch of its stroke. This arrangement makes it so economical in use of pressure that air is always used in preference to steam, and it has never caused any trouble with train brakes.

This little machine has no outward moving parts except the rod. Its valve is attached to the piston.

THE SANSOM BELL RINGER.

The Sansom bell ringer is operated by the admission of compressed air pressure under the piston, which forces piston upward and carries a connecting rod attached to a crank on the bell shaft, as shown in Fig. 1. When an arm, extending on the left of the

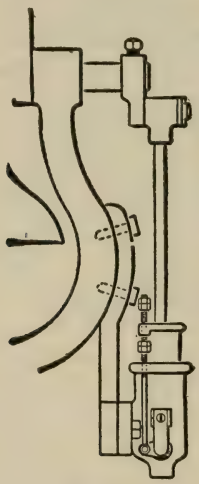


FIG. 1.
The Sansom Bell Ringer.

piston has traveled to the upper set of lock nuts on reversing rod, the admission port begins to close and the exhaust port to open, thus allowing the air to escape from the cylinder and the weight of bell to force piston to bottom of cylinder.

When the arm on the left has traveled to the lower set of lock nuts, the exhaust port begins to

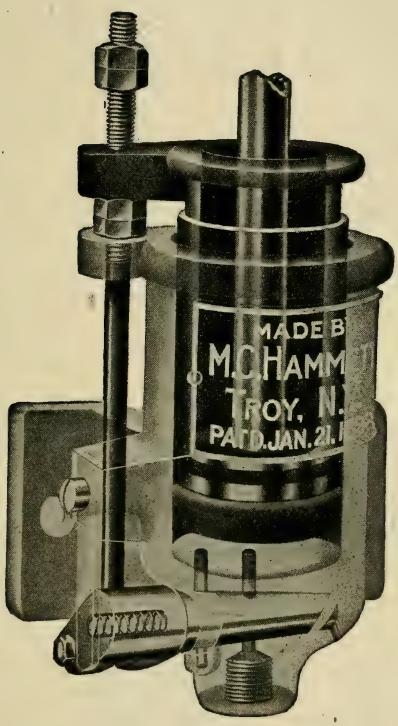


FIG. 2.

The Sansom Bell Ringer, Showing Internal Mechanism.

close and the admission port to open, thus again forcing the piston upwards, as before described. Fig. 2 is a transparent view of the bell ringer, showing the working of the valve within.

The variation in the stroke of the ringer is made by adjusting lock nuts on reversing rod. To increase the throw of bell, raise the upper set of lock nuts; to decrease throw, lower them.

THE CHICAGO LOCOMOTIVE BELL RINGER.

The Chicago Locomotive Bell Ringer, as shown in Fig. 1, is so nearly similar in operation that the

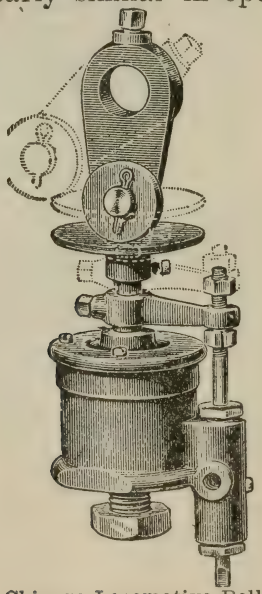
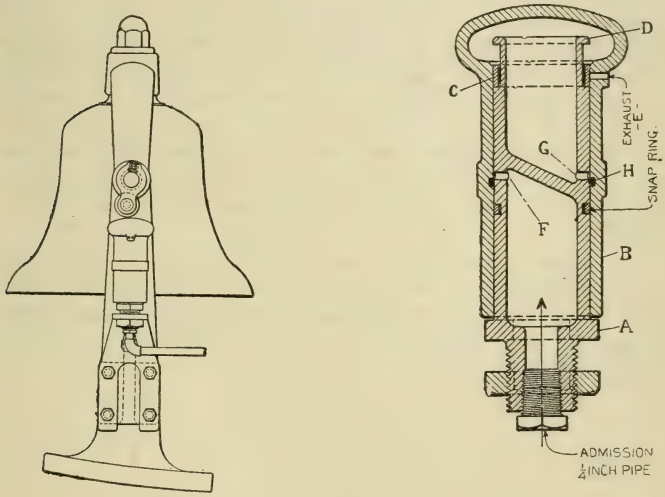


FIG. 1. Chicago Locomotive Bell Ringer.

engraving suffices for an explanation after the principles of the foregoing devices have been described.

SECURITY BELL RINGER

The Security bell ringer consists of a rigid piston and movable cylinder the top of which is crown-shaped for contact with the roller. All toggle joints and other adjusting rods are dispensed with, so that when the bell cord is used the bell ringer is not brought into action. The working parts are entirely protected from cinders and the annoying consequences from snow or water freezing as in open top bell ringers, and by excluding these elements the life of the bell ringer is greatly prolonged.



Security Bell Ringer

The Security allows free exhaust on the down stroke and is not subjected to the strain of other bell ringers where air is withheld for compression. The period of intake is of short duration and the air filling the upper chamber is fully utilized by expanding to the end of the stroke, when the exhaust port is opened.

Adjustment of piston "A" is provided for by threaded

bracket and large lock nut. This bracket can be bent to suit bell frame or turned downward and attached to base bracket. Air is admitted through passage "H," causing cylinder to rise, thereby automatically shutting off the intake on its upward movement, while the exhaust ring "C" is carried up by the cylinder until interrupted by the retaining ring "D," when exhaust port "E" is opened, immediately permitting cylinder "B" to return of its own weight until exhaust ring "C" again rests on shoulder of piston "A," when a slight pressure of the roller on top of cylinder head completes the downward operation of cylinder "B," thereby closing exhaust port E," and opening communication with intake "F."

Long experience with various bell ringers has demonstrated that a bell ringer without snap rings is only serviceable for the first few days' service, after which air leaks out. This bell ringer has a specially ground bottom snap ring and the wide top exhaust ring "C" for controlling exhaust. These two snap rings, together with the liberal area of both piston and cylinder, constitute the working parts, thus insuring maximum service, there being practically nothing to get out of order.

For a heavy weight bell the clearance under roller should be one-sixteenth of an inch, and for a light bell one-eighth inch space should be allowed. Crank arm should be set at an angle of about five degrees ahead or back of center line to avoid dead center when bell is at rest.

AUTOMATIC STEAM BLOWERS.

THE HUFF AUTOMATIC STEAM BLOWER.

This automatic steam blower is a simple and novel device inserted in the blower pipe immediately over the steam chest, and auxiliary to the regular blower valve in the cab. By its use the blower automatically goes to work whenever the throttle is closed, and automatically ceases blowing whenever the throttle is opened, the force of the blower blast being regulated by the blower valve in the cab.

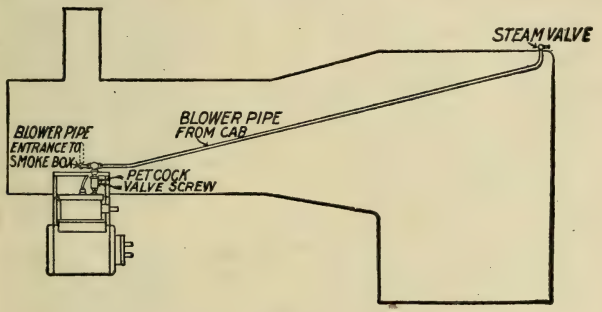


FIG. 1.
Huff Automatic Steam Blower.

It is well known that the proper and regular use of the present hand blower for the purpose of preventing the smoke and gases trailing back over the train and coming out into the cab when the engine is shut off requires much care and attention on the part of the fireman, and that it is seldom accomplished in practice.

The location and connections of this device are shown by Fig. 1. It will be noticed that it can be easily and quickly installed. The arrangement and working of the internal parts are shown by Fig. 2 and the external appearance of the complete device, ready for installation, is shown by Fig. 3.

To install this device, a piece of the blower pipe about four inches long is cut out at a point directly over the steam chest; the ends of the two remaining parts are threaded, the device inserted, and a one-inch pipe connection made between the bottom of the cylinder *A A* (at the point *N*, Fig. 2) and the top of the steam chest.

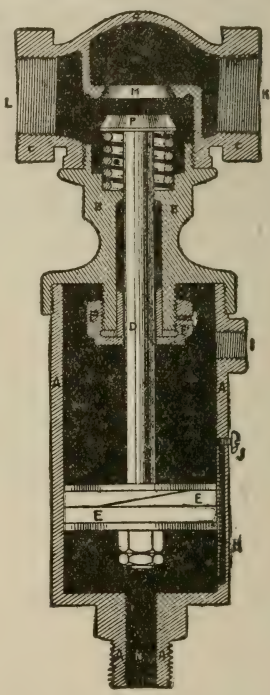


FIG. 2.
Huff Automatic Steam Blower.
(Sectional View.)

It is assumed that the blower valve in the cab is always kept open to some extent; under these circumstances, steam at full boiler pressure always fills the blower pipe from the cab down to the valve *F*. When the throttle is opened, the steam in the steam chest (see part numbered 44, plate "The American Steam Locomotive") exerts an upward pressure on the piston *E E;* the area of the piston *E E* being much greater than the area of the valve *F*, the excess of upward pressure on the piston *E E* over the down-

ward pressure on the valve F results in the seating of the valve F, so that as long as these conditions continue the blower cannot blow. When the throttle is closed the boiler pressure acting downward on the small area of the valve F is nevertheless greater than the atmospheric pressure (in the steam chest) acting upward on the piston E E, and the valve F is, therefore, forced down from its seat M (being cushioned by the spring G), and the blower goes to work automatically.

FIG. 3.
Huff Automatic Steam Blower.
(External View.)

In the rare emergency of wishing to keep the blower at work when the engine is using steam it is only necessary to open the screw valve J and plug the exhaust opening I, under which circumstances the piston E E will be in equilibrium with the same steam pressure above and below it, and the boiler pressure in the blower pipe will open the valve F, and the blower will go to work and remain at work (whether the throttle is open or shut) as long as the blower valve in the cab is left open.

This automatic steam blower thus provides a means by which the judicious and economical use of the old blower valve may be accomplished—the smoke and gases from a passenger engine may be largely prevented from trailing over the train when the engine is shut off—thus greatly increasing the comfort of passengers, and particularly those who use trains which are running in local and suburban service.

The crews of all engines, whether passenger, freight or shifting, may be relieved of the annoying and harmful effects of smoke and gases coming into the cab when engines are shut off; this is very annoying even when coal is used as a fuel, but almost intolerable when coke is used; besides this, it seems to be necessary to make some provision for keeping a coke fire bright when the engine is not working, and this device provides a positive and automatic means of accomplishing this. Finally, the automatic action of this

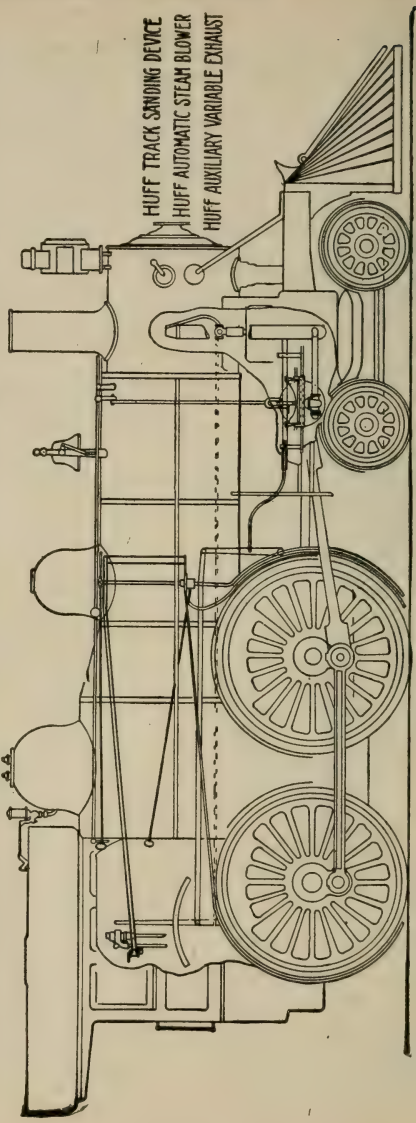


FIG. 4. Huff Locomotive Attachments.

device would relieve the fireman of much of the work of "hooking" or stirring up the fire.

Fig. 4 shows the application of this and other locomotive attachments by the same manufacturer.

CHICAGO & NORTH-WESTERN R'Y BLOWER VALVE.

The automatic blower valve used by the Chicago & Northwestern Railway on suburban locomotives to prevent black smoke is a valve operated by compressed air, which is admitted mechanically by the opening and closing of the locomotive throttle in the cab.

Fig. 5 shows view of boiler head with arrangement of the device employed for this purpose. The air controlling valve with connections to the aux-

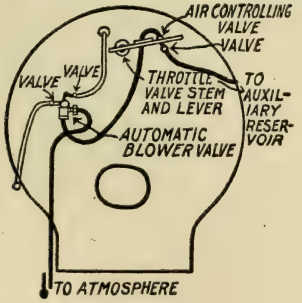


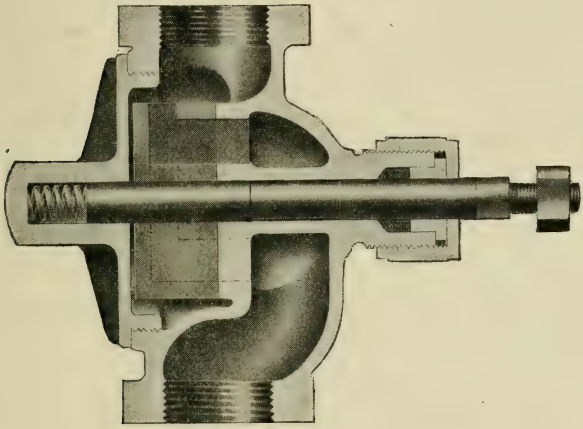
FIG. 5.
C. & N-W. R'y Automatic Blower Valve.

iliary reservoir of the driver brake and to the automatic blower valve is shown located just back of the throttle lever. When the throttle is closed all communication between the two is closed, but when

the throttle is opened the air pressure automatically unseats the small controlling valve and passes to the blower valve where it acts upon a piston, closing off the steam from the blower pipe in the smoke box. In case it is not desired to have the blower work when the locomotive is standing, the usual blower valve is closed. It is by the amount of opening given this latter valve that the severity of the automatic blower is regulated.

LOEDIGE QUICK ACTING BLOWER VALVE

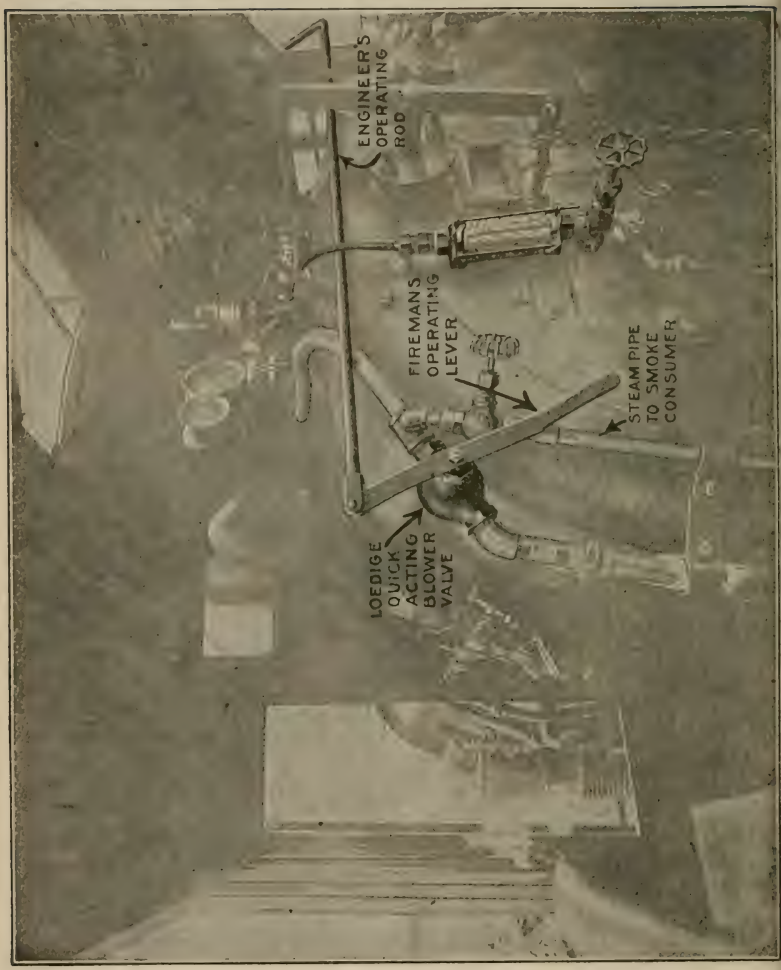
The accompanying illustrations show first, a section through the body of the Loedige Quick Acting Blower Valve, showing its construction similar to the rotary valve of the engineer's air brake valve, and second, a view of the back boiler head of a locomotive with this valve applied and connections for its operation by either the engineer or the fireman.



Loedige Quick Acting Blower Valve

It is considered preferable to have this operating lever also within reach of the engineer, as shown, so that this valve can always be operated instantly by the engineer, should the fireman be otherwise engaged.

This valve has been quite largely applied in conjunction with a multiple tip blower and steam-air jets in the fire-box for the elimination of smoke in large cities.


ENGINEER'S OPERATING ROD
FIREMANS OPERATING LEVER
STEAM PIPE TO SMOKE CONSUMER
LOEDIGE QUICK ACTING BLOWER VALVE

VARIABLE EXHAUST NOZZLES.

The history of expanding exhaust nozzles is nearly as old as the locomotive itself. Ever since the locomotive was first constructed there has been a feeling among practical men that there should be some means of controlling the exhaust opening to a certain degree in accordance with the amount of steam being used in the cylinders. Experience has shown that when a stationary nozzle is used the various conditions under which a locomotive is worked produce, at times, wasteful results in fuel economy, and under many conditions the contracted opening of the nozzle gives too great a back pressure in the cylinder, thus decreasing the speed and efficiency of the locomotive.

The stationary nozzle must be made small enough to get the desired draft on the fire when the engine is working the least practical amount of steam in the cylinders, and when it becomes necessary to "drop the lever" and work more steam in the cylinders the increased velocity of the exhaust through a restricted opening of the nozzle tears the fire on the grates, thus rushing the gases and finer coal unconsumed through the flues and causing wasteful results. The holes torn in the fire also admit cold air through the grates, cooling the flues and fire-box suddenly, and causing them to leak. There is no doubt but what many engine failures due to leaky flues may be attributed to this cause.

To overcome these difficulties many forms of

expanding nozzles have been devised, most of them, however, being designed to be operated manually by the engineer, but the neglect of the latter to properly and constantly use them caused them to quickly become inoperative by corrosion and gumming up due to the heat and gases of the front end.

WALLACE & KELLOGG'S VARIABLE EXHAUST NOZZLE.

The automatic variable exhaust nozzle here shown has been in use for several years, and is claimed to have overcome by its automatic action many of the

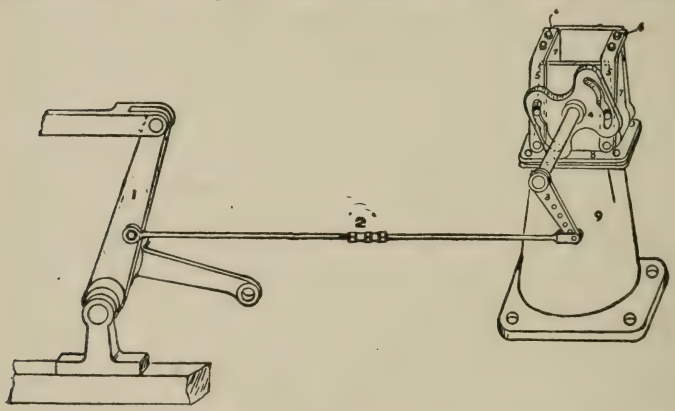


Fig. 1.
Wallace & Kellogg's Automatic Variable Exhaust Nozzle.

serious objections to former devices. The movable wings are connected to a rotating cam, which in turn is connected to a shaft extending through the smoke-box. To this latter shaft, by means of a crank *I* and adjustable rod 2, connection is made with the reverse lever or lifting arm 1. Therefore the operating of

the nozzle is automatically adjusted to correspond with the amount of steam that is being used in the cylinders at all times. When the reverse lever is hooked up toward the center of the quadrant the nozzle is the smallest. When the lever is in either forward or back extreme position of the quadrant the nozzle is the largest.

The adjustment of the nozzle may be altered in a moment's time by simply moving the front end of the connecting rod 2 up or down on the crank *I*, thereby giving it correspondingly less or increased travel, as desired.

On account of the frequent changes of the reverse lever this nozzle, it is claimed, cannot become gummed or corroded so as to render it inoperative.

THE HUFF AUXILIARY VARIABLE EXHAUST.

The exhaust nozzles of locomotives are made small enough in diameter to give sufficient blast to stimulate the fire and generate the necessary amount of steam when the valves are cutting off short and the steam is being used expansively; this results in the blast being too strong at certain other times, when the valves are cutting off later, and the terminal pressure is higher; this excess force of blast is detrimental in two ways: first, by increasing the back pressure in the cylinders; second, by tearing the fire and causing excessive coal consumption. The Huff automatic variable exhaust provides a means by which these objections are overcome.

In applying the device to a locomotive the exhaust passages are tapped at convenient points between

the cylinders and the smoke-box and pipes led back through the saddle; these pipes (which should be at least two inches in diameter and larger, if possible) are connected with a reservoir or drum located immediately back of the saddle, as shown in Fig. 4; this drum is provided with a vent and valve, which preferably should be operated by a connection from the lift shaft, so that the vent opening will be greater when the reverse lever is at either end of

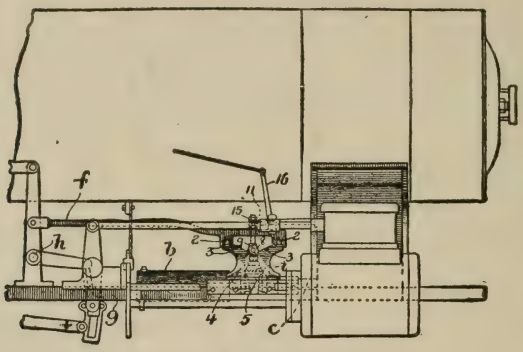


FIG. 1.
Huff Automatic Variable Exhaust.
(Side View.)

the quadrant, and less when the reverse lever is in mid-gear. The escaping steam from the vent may be piped to any convenient discharge point, as, for instance, up the back of the stack.*

The application of the apparatus to a locomotive, and the relative arrangement of the parts, is shown by Figs. 1, 2, 3 and 4. Figs. 1, 2 and 3 show the application to a locomotive fitted with double exhaust nozzles,

*The reader is referred to the plate of the "American Type Locomotive," to arrive at a clear understanding of the location of the ordinary locomotive parts herein referred to.

while Fig. 4 shows a possible alternative application to a locomotive fitted with a single exhaust nozzle; in the former case, however, two small drums were used instead of one large drum, owing to the fact that the intervening space was already occupied by the main reservoir of the air brake system. The arrangement of parts for the double exhaust locomotive (Figs. 1, 2 and 3) is as follows:

The openings in the top of the cylinder saddles, marked *e e*, Fig. 2, are the points where the exhaust

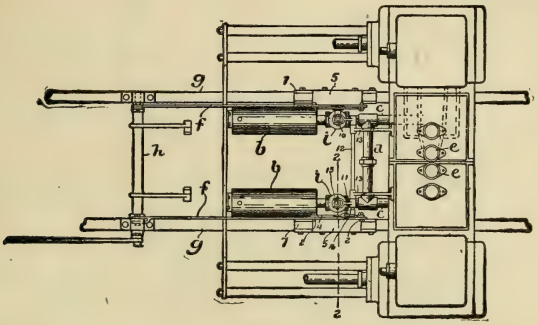


FIG. 2.
Huff Automatic Variable Exhaust.
(Plan View.)

base and nozzles are attached; *c c* are the pipes which are tapped into the exhaust; *d* is a cross-pipe connecting the two; *b b* are the drums; *i i* are gate valves inserted into the pipes *c c* back of the cross-pipe *d*. The mechanism for operating the gate valves from the lift shaft in this case involves the use of special slides working in guide bases which are attached to the frames, the slides being made with inclined slots which engage rollers attached to the vertical stems of the gate valves. As the slides have a horizontal

motion, imparted by connections from the lift shaft, the gate valves have their maximum opening when the reverse lever is in either extreme position, and their minimum opening when the reverse lever is in mid-gear. The several parts comprised in this mechanism for working the gate valves from the lift shaft are shown in Fig. 1 and marked *f*, *g*, *h*, 2, 3, 4, 5, 6, 7, 8 and 9. An auxiliary apparatus is also provided,

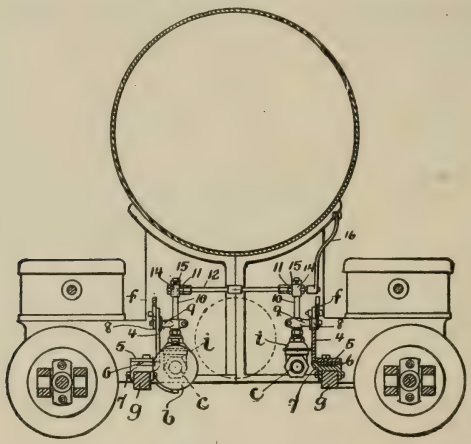


FIG. 3.
Huff Automatic Variable Exhaust.
(Front View.)

by which the gate valves may be operated from the cab independently of their control by the reverse lever when the engine is cut back. The parts of this auxiliary apparatus are shown in Fig. 3, and marked 11, 12, 13, 14, 15.

It has been stated that the drum or drums should be fitted with a vent and valve to control the discharge of surplus steam to the atmosphere; in the particular

application shown by Figs. 1, 2 and 3 this vent and valve were located on the lower side of one of the drums (which was the only available point) and the valve was adjustable by hand only; the lift shaft connection was, therefore, made with the gate valves *i i* instead.

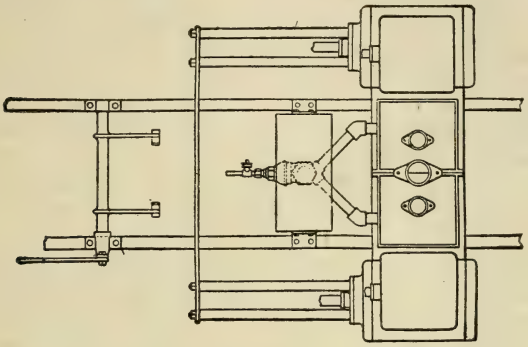


FIG. 4.
Huff Automatic Variable Exhaust.
(View from Under Side of Locomotive.)

Service trials of the Huff variable auxiliary exhaust on a double exhaust locomotive have shown a coal saving of about sixteen per cent. on the ton mile basis. It is probable that this result was attributable to two influences: first, a portion of each exhaust was by-passed around to the other side and discharged into the stack through the nozzle which was not in action at that time, thus both relieving the back pressure and making the exhaust into the stack more regular and uniform than it otherwise would have been; second, by venting to the atmosphere through the vent on the under side of the drum

any excess of steam over and above what was necessary to develop sufficient blast under the particular circumstances and conditions then existing.

THE ECONOMY EXHAUST NOZZLE.

It has been demonstrated on testing plants and in road service that the circular exhaust nozzle fails to deliver the exhaust steam jet into the stack in a form that possesses the highest efficiency as a draft producer. The general use of a bridge in such nozzles tends somewhat to improve the situation.

The Economy Exhaust Nozzle is furnished in either the rectangular or dumbell shape, having its longer axis longitudinal with the engine. Thoroughly conducted tests show that it meets all of the requirements imposed by exhaust passages and stack conditions.

The claims made for this type of nozzle are: It avoids the use of bridges in nozzles entirely and the attendant back pressure which their use involves; it avoids cross-firing in the stack; it improves the draft on account of offering a larger surface to the steam jet to induce the draft; it is especially advantageous in large engines where it is so difficult to maintain the distance from top of nozzle to top of stack that is properly required to obtain the best results with the circular nozzle.

The relative action of the exhaust with the ordinary circular and with the Economy rectangular nozzles is shown in the illustration.

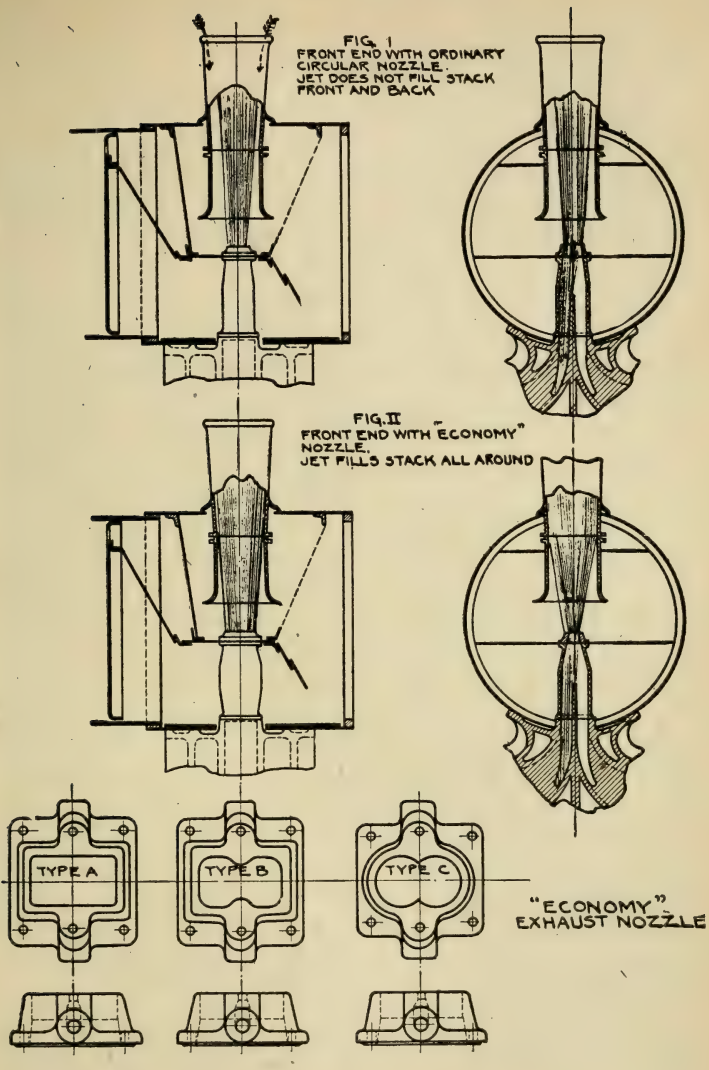


FIG. I
FRONT END WITH ORDINARY CIRCULAR NOZZLE.
JET DOES NOT FILL STACK FRONT AND BACK
FIG. II
FRONT END WITH "ECONOMY" NOZZLE.
JET FILLS STACK ALL AROUND
TYPE A
TYPE B
TYPE C
"ECONOMY" EXHAUST NOZZLE

THE WALLACE & KELLOGG AIR-PUMP EXHAUST FEED-WATER HEATER AND CYLINDER LUBRICATOR.

The construction of this appliance is as follows: A three-way cock is used in connection with exhaust port of air pump. It is placed near the air pump. Attached to this cock is a lever that extends into the cab and is operated by the engineer. Also two exhaust pipes are connected to this cock, one extending over cab and exhausting directly into the feed water in the tender, the other pipe extending to the smoke box and live steam ports or steam chests. The branch pipes to the steam ports are provided with check valves. A check valve is also placed in the pipe leading to the smoke box.

The three-way valve is for the purpose of conducting exhaust steam into the feed water or otherwise at the will of the engineer. When opened in opposite direction, and the engine is working steam, the exhaust is conducted to the stack, but when the engine is shut off, the exhaust is admitted to the two steam chests and cylinders by the automatic opening of the checks in the two branch pipes. The check in the pipe leading to the stack prevents smoke and cinders from being drawn into the cylinders when the engine is drifting.

The live steam ports are provided with automatic drip valves situated at the lowest point in cylinder

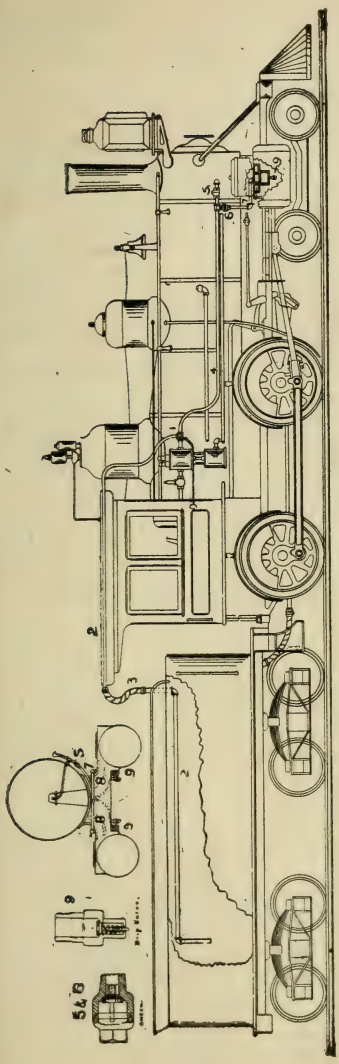


Fig. 1. Air-Pump Exhaust Feed-Water Heater and Cylinder Lubricator.

saddles for the purpose of draining condensation when the engine is at rest.

The small sectional cuts shown above the locomotive tender in the accompanying engraving clearly illustrate the details of the check valves, drip valves, etc., and their location.

Among the many advantages claimed for this device are the following:

It is noiseless. This avoids the frightening of teams or the annoyance to passengers around stations. It does not create a draft on the fire when the engine is at rest, as does the old method.

This advantage results in the saving of fuel. It acts as a lubricator to the valves and cylinders when the engine is not working steam. The exhaust

steam from air pump circulates through the steam chests and cylinders, keeping them at a uniform temperature, not allowing them to chill in cold weather when engine is at rest, or overheating or cutting of cylinders while drifting down grade due to the friction of the piston traveling to and fro. The relief valves on the steam chests can be dispensed with, as the air pump exhausting into same performs their functions to a large degree. There is a large saving of fuel effected by the heating feed water to as high a temperature as injectors will work. This also makes a better steaming engine. It also reduces wear on valves, valve seats, cylinders, etc., to a minimum by perfect lubrication. It is beneficial to the working of the air pump, as there is a partial vacuum formed in the exhaust pipe from the pump to the live steam ports when the engine is drifting shut off, as on heavy grades when the air pump is working the hardest. The water in the tank being warmer than the atmosphere, the tank never sweats, thus preserving the life of the paint on the tank and keeping it bright and fresh. The device is simple, cheap in its construction and is claimed to effect a saving of fifty per cent. in cylinder oil and two per cent. in fuel.

BOILER CLEANERS.

It has been said that the saving to be effected in power generations to-day consists more in the overcoming of simple practical difficulties in the use of that which we already have than in any revolutionary invention. The man who could supply a simple, inexpensive means of furnishing steam boilers with pure water, which, when evaporated, would leave nothing behind it, would do more to decrease the average cost of power production than the man who develops the compound engine. Such a process would have to be so cheap in first cost as to warrant its use in comparatively small plants, and so simple as to require attendance of no higher order than that found about the ordinary boiler plant.

THE McINTOSH PNEUMATIC BLOW-OFF COCK.

It is now generally conceded that when the water used for locomotives is bad and cannot be purified before entering the boiler the best way to dispose of the impurities is to keep them loosened up with soda-ash or some other kind of boiler purge, and remove them by washing out or blowing off the water from the boiler before they have opportunity to incrust upon the flues or sheets.

The frequent washing out of boilers has two disadvantages: first, it consumes considerable time, which may seriously interfere with transportation in busy times; and, second, bad results follow the

frequent cooling down and reheating of boilers, causing undue expansion and contraction, with the accompanying cracking of sheets and leaking of flues.

The more frequent and thoroughly the water in a boiler is blown out, the longer can be the interval between washings-out. To accomplish this, it is desirable to have several cocks easy of manipulation in the lowest parts of the boiler for getting rid of the heavier impurities, and a surface cock for removing from the surface of the water any light animal or vegetable matter that would tend to cause foaming or the water raising in the boiler. To accomplish this many styles of blow-off cocks have been used. One device, quite general in its use, is the McIntosh pneumatic blow-off cock.

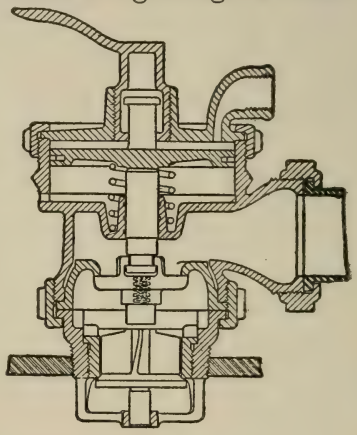


FIG. 1.
McIntosh Pneumatic Blow-Off Cock.
(Sectional View.)

Fig 1 shows a side and sectional view of this cock, which will be seen to consist of two check valves (*A* within the shell of the boiler and *B* without), and a piston operated upon by air and released by a spring. Fig. 2 gives a view of the boiler head in the cab of a locomotive, indicating the air piping and operating valves, with large detail of the latter. When air or steam (preferably air) from a small valve in the cab (see Fig. 2) is admitted to the outward or

top side of the piston, as it appears in the engraving, Fig. 1, it acts against the piston, which shoves both check valves open and holds them open against

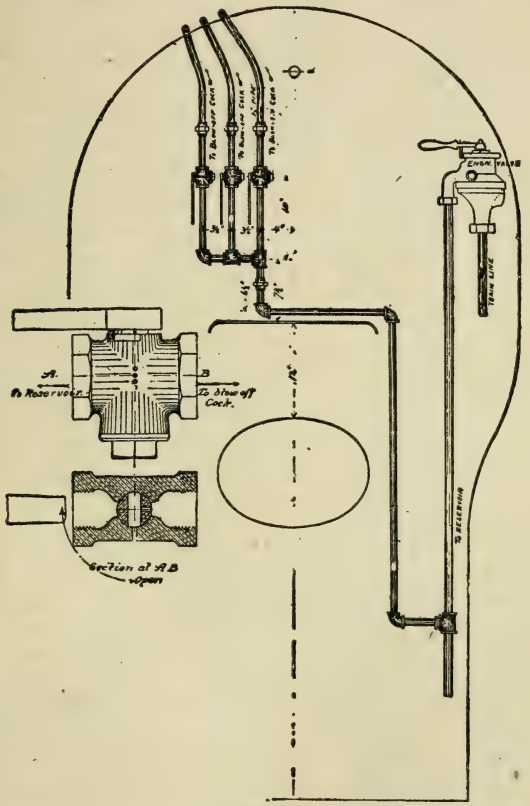


FIG. 2.
Cab Operating Valve Arrangement, McIntosh Blow-Off Cock.

the pressure in the boiler, on account of the area of the piston being the greater. When the air is exhausted from the piston the boiler pressure, aided

by the spring, causes the piston to assume its normal position as shown in the engraving.

Each blow-off cock has a discharge pipe leading either to the side of the locomotive or toward the back, in order to blow the impurities away from the machinery and boiler itself.

Should there be no air pressure on hand with which to operate the pneumatic cocks on an engine, the cock may be opened by screwing down (or in) on the outer handle *C*, which acts the same as the pressure on the piston, namely, forces the valves in and opens them. On the contrary, although both the check valves require to be held open before any discharge or leakage can occur, should dirt or grit get into the cylinder portion in which the piston works, or should no oiling be given the piston for a long time, the latter might stick in open position, in which case the handle of the screw should be turned back, thereby permitting the check valves to reseat themselves.

Should scale hold either or both check valves from their seats, it is generally advisable to open the valves wide several times and let them close suddenly. This will usually crush the hardest scale.

When locomotives are supplied, as shown in Fig. 3, with both surface and lower blow-off cocks, it is considered the best practice to use the surface cock *A* when the locomotive is working hard and the water is in a state of violent ebullition, carrying the impurities to the surface. At terminals, and if the boiler is foul occasionally on the road after steam has been shut off long enough for the sediment to settle, the lower blow-off cocks should be opened while both injectors are working and two or three gauges of water blown out.

While there is no packing of any kind about this cock, to keep it in perfect order the cap of the air cylinder should be removed about once a month and

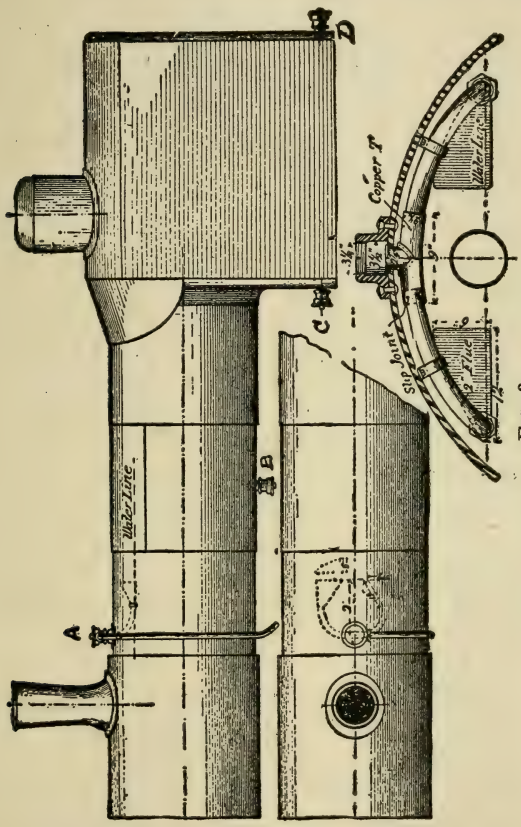


Fig. 3.
McIntosh Pneumatic Blow-Off Cock, Showing Arrangement of Blow-Off Cocks on a Boiler.

the cylinder wiped out and oiled. By leaving a plug in some convenient tee of the air pipe in the cab oil may be injected therein more often if desirable.

Fig. 2 shows a convenient cab arrangement for three blow-off cocks on a locomotive. As shown, the air is taken from the main reservoir connection of the engineer's brake valve, and each operating valve consists of a one-half inch air stop cock with a small hole drilled through one side to form a three-way cock for exhausting the air from the cylinder of the blow-off cock after the cab operating valve is closed.

Should it require considerable supply of air to operate any one of the blow-off cocks, it will be found that there is a leak in the air pipe between the cab operating valve and the blow-off cock, or a bad leak by the packing ring of the latter. Its correction is obvious.

A boiler equipped as shown in Fig. 3 may be kept clean by frequently blowing out; it will develop fewer cracked firebox sheets and leaky flues, and will require washing out less often. The engine will work dryer steam and carry less scale and dirt through the valves and cylinders, thus requiring less cylinder oil and producing less wear to the valve motion; it will use less water, make more ton-miles than a locomotive not so equipped, and the loss of water and heat occasioned by blowing out will be compensated for several times over.

THE HORNISH MECHANICAL BOILER CLEANER.

This cleaner is in two parts, all inside the boiler, except the air valve and the blow-off pipe and cocks. One part is in the forward end of the boiler and reaches from side to side, using the front head as a back to which it is riveted. It extends under the dry

pipe*, and is also riveted to the sides of the boiler, as shown in Figs. 1 and 2.

The space between the flues and the dry pipe is

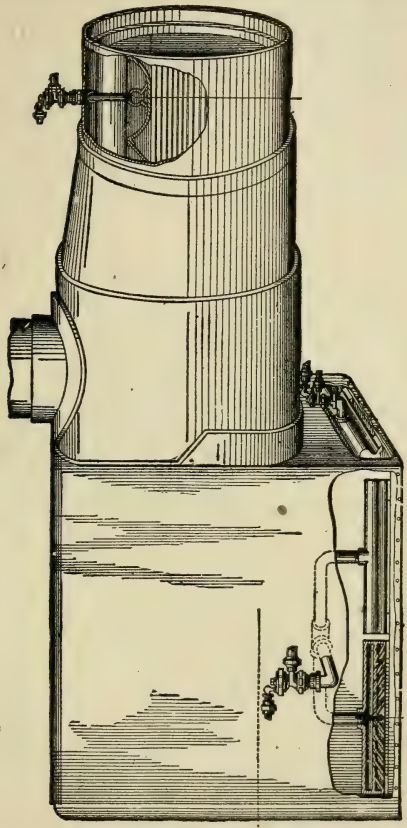


FIG. 1.
Hornish Mechanical Boiler Cleaner.

used for the skimmer, see Fig. 2. It makes a perfect surface skimmer the full width of the boiler, and at the same time, forms a basin holding from twenty to

*See part numbered 191, plate "The American Type Locomotive."

thirty gallons. This makes a large storage capacity in which to collect and settle all the impurities that the skimmer takes from the surface. The basin holds the skimmings and settlings which can be blown off at the will of the engineer. The impurities are carried to the skimmer by the natural circulation in the boiler. The fluctuations of the water line do not affect the proper working of this device.

Within the skimmer is an arrangement for blowing off what solid matter it catches, thus practically preventing any waste of water when the skimmer is blown off, and between these times it is claimed that there is a continuous automatic drawing off.

The other part is in the leg of the boiler, as shown in Fig. 1, and cannot be put in except when the boiler is first built, or when a new fire box is put in. It is the same kind of a device that empties the skimmer as just described. It sits on top of the mud ring, the "suckers," which are raised one inch above the mud ring by legs on the draw-off head, facing down. The openings of all the suckers are the same size, but their small ends vary in size. If they were all the same size, the openings nearest the center would pass all the sediment, and those further along the head would not pass their share. (This is due to the fact that all liquids under pressure will seek the nearest outlet first.) To overcome this, the small end of the sucker nearest the opening in the center of the draw-off head is made the smallest, and the size of the others increases with the distance from the center. The matter surrounding this is always water soaked, and is a soft slush, which is easily removed by the pressure in the boiler.

As the impurities are over and around the draw-off head in front of the water and steam, the pressure in the boiler pushes them out through the suckers into the blow-off pipe before any water or steam can pass through. There is no waste of water, as the blowing off is stopped as soon as the water shows clear. This is what reduces the waste of water to a minimum. The draw-off head here shown is a great improvement over the old head formerly used; even if they should stop up from neglect, they can be

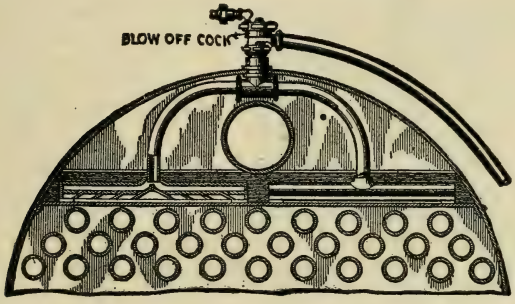


FIG. 2.
Hornish Mechanical Boiler Cleaner.
(Sectional View Through Front of Boiler.)

cleaned from the outside by forcing water through them. They cannot scale up, since there is no heat next to them from the fire box. Each part of the cleaner is a companion to the other, and what one leaves undone the other does. The two must be used together to obtain perfect results.

When the water is boiling the impurities come to the surface in a boiler the same as in an open vessel. The proper circulation in a locomotive boiler is down to the belly of the boiler after water leaves the check,

then down the forward leg along the side and up the back leg over the crown sheet, and forward over the top of the flues, striking the front head of the boiler, from which point it starts to repeat the same course over again. It is here at the front end of the boiler and at the surface that the skimmer intercepts the impurities, settling and removing them before they have time to touch the hot flues or hot sheets. This not only prevents foaming, but leaves nothing in the boiler to make scale and lessens the accumulation in the leg of the boiler.

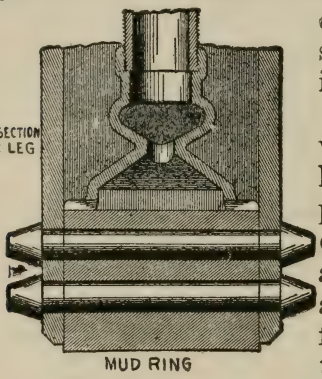


FIG. 3.
Hornish Mechanical Boiler Cleaner.
(Section Through Mud Ring.)

Nothing but water will make steam, so keep grease and compounds out of the boiler. Heat is the best agency known for separating solid matter from water. A boiler is the best contrivance yet devised by man for heating water; as most of the solid matter contained in the feed water comes to the surface when steam is up, that is the best place to remove it. It is claimed that the surface skimmer does this before it starts to make the second round with the circulation, and what little is left goes to the leg of the boiler and is removed by the mud ring device; this prevents foaming, reduces the number of washings out, prevents incrustation and corrosion, and is claimed to have been found more practical than purifying the water before entering the boiler.

It is the soft matter in the boiler that is dangerous; the removing of that part removes the danger.

This device does not interfere in the least in cleaning out the old way, or in the use of compounds. If scale should form from neglecting to use the cleaner, or any other cause, compounds can be used, and what they dissolve and throw down the cleaner will remove at the surface and at the leg. As both cleaners are blown off before entering the round house, there is little or nothing left in the water, and what there is it catches while the engine is idle, to be blown out again as soon as it leaves the roundhouse. This makes a clean boiler at all times.

If boilers are allowed to become cold before removing the water, very little scale will form on the flues and sheets. It is removing the water for washing out while hot, to save time, that causes them to scale so fast and also makes them leak.

As foaming is eliminated, no solid matter goes over with the steam to cut the valves, valve seats, valve stems or packing. The cylinders, too, are kept smooth, and when free from grit their wearing surface soon acquires a gloss that insures easy working and long wear, together with a minimum use of oil. This is of great value for balanced valves, which are now coming into use with high pressure.

It is the effective heating surface that counts, and not the large amount. The more rapid the circulation is the more times it will pass over the heated surface in a given time, and a smaller heating surface with a rapid circulation is better than a larger heating surface with a more sluggish movement of the water. The thinner the liquid is the more rapidly it will circu-

late, and as it becomes thicker its movements will become slower. It is the impurities left in the boiler instead of being removed that causes the water to thus thicken.

Directions for its use upon locomotives.—Use surface blow-off after leaving and before entering roundhouse at each end of the division, also once or twice between terminals on each trip, blowing from one to one and a half minute each time. The best time to blow off the surface cleaner is when the engine is doing the hardest work. Should boiler foam from any cause, use surface blow-off for instant relief. The mud ring device is used only at each end of terminals, just before and after leaving the roundhouse.

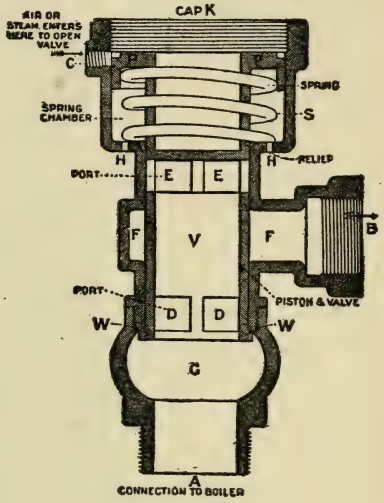
CLIMAX BLOW-OFF COCK.

To Open the Blow-Off Cock.—When a three-way cock in the cab is turned, air or steam (the former is more desirable, especially in cold climates) is admitted through a pipe at port *C* to the upper side of piston *P*. As the upper side of piston *P* is more than twice as large as the bottom end of valve *V*, which is exposed to boiler pressure of chamber *G*, piston *P* and its valve *V* will be moved down by a pressure of air somewhat less than half what is in the boiler at the time. When this movement has taken place it will be seen that water in the enlarged cavity *G* can pass through the ports *D-D* up through the inside of valve *V*, out the ports *E-E* into the annular opening *F* leading to the atmosphere at *B*.

To Close the Blow-Off Cock.—Turn the three-way cock in the cab to its original position, which exhausts

all pressure from *C* and the top of piston *P*. The boiler pressure from *A* now acts against the bottom of valve *V* and forces valve and its piston up to position shown in cut, and the valve makes a joint at *W-W*, thereby preventing any further wastage of water. Scale or dirt caught in the ports *D-D* or *E-E* would be sheared off when the valve closes, and

A—Connection to Boiler.
B—Blow-Off to Atmosphere.
C—Air or Steam Connection.
D-D—Intake Ports of Valve V.
E-E—Outlet Ports of Valve V.
F-F—Annular Opening to Blow-Off at *B*.
G—Annular Opening to Intake Ports *D*.
H-H—Vent Ports of Spring Chamber.
P-P—Piston.
K—Cap for removing Piston, Spring and Valve.
S—Spring.
V—Valve and Piston *P*, combined.
W-W—Valve Seat when closed.



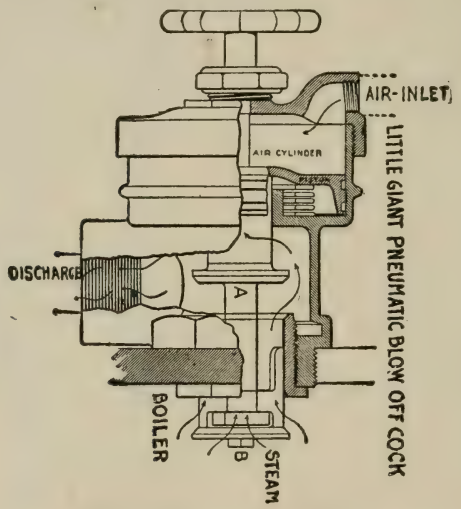
Climax Blow-Off Cock.

scale on seat *W-W* ordinarily crushed. If the valve fails to close tight, open and close it quickly a few times until it forms a tight seat at *W-W*.

The spring *S* is for the purpose of preventing the valve opening from any vacuum formed when the boiler is cooling down. Hence, if the valve leaks at such time, cap *K* should be removed and this spring examined.

THE "LITTLE GIANT" PNEUMATIC BLOW-OFF COCK.

The acompanying engraving shows clearly by arrows the flow of pressures and fluids when this blow-off valve is in operation. Air pressure has entered the air cylinder and forced the piston, with its attached valve inside the boiler, to the right, allowing the water and the sediment in the boiler to es-

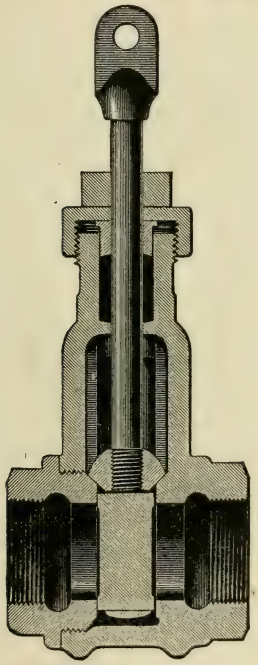


Little Giant Blow-Off Cock.

cape. When the air pressure is withdrawn the spring behind the air piston returns it and the boiler pressure against the valve assists in the return to its seat. Should some scale or other substance remain beneath the valve *B*, by screwing in on the hand wheel, valve *A* may be forced to a seat, thus rendering this valve remarkably safe against failure to close.

THE JOHNSTONE BLOW-OFF VALVE.

This is a form of gate valve operated by a suitable lever at the will of the engineer. These valves have been largely used on locomotives, and are much superior to an ordinary globe valve for this purpose, as particles of scale will not prevent their proper closing.



Johnstone Blow-Off Valve.

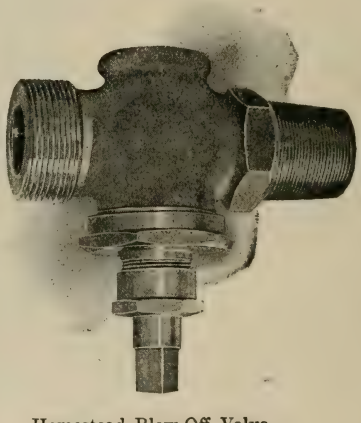
The sliding valve is attached to the stem by means of a stirrup, shown just under the valve, and which loosely encloses it, and thus permits it to freely adjust

itself to the seat it forms at the side opposite the attachment to the boiler.

By a lever connected to the stem the valve can be raised entirely from its seat, so that there is a full straight-way opening through the valve body. The sliding of the valve under pressure maintains its surface and its seat in close contact, and if any scale or other foreign matter tending to impair such contact intervenes, it is destroyed or displaced by the attrition of the parts when so operated.

THE HOMESTEAD BLOW-OFF VALVE.

This valve serves a purpose similar to that last described. A long wrench extending up through the running board or deck permits its use while the locomotive is in motion.

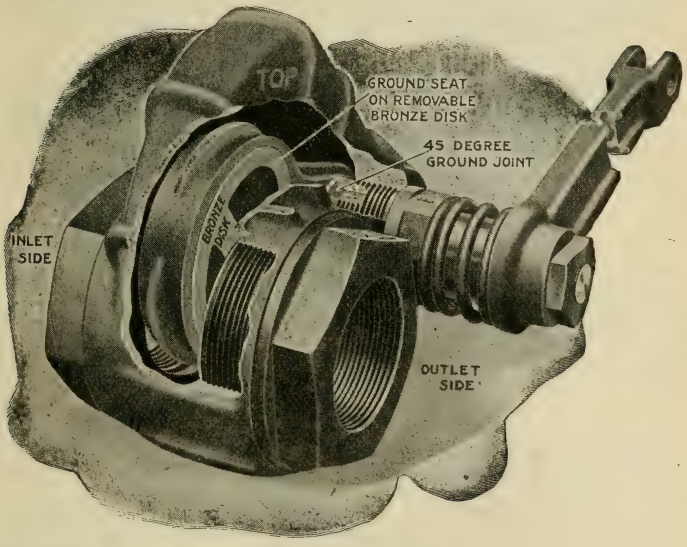


Homestead Blow-Off Valve.

While the cut here shown gives an exterior view, its internal arrangement is identical with that of the "Homestead Straight-Way Valve," shown elsewhere. One-quarter turn opens the valve wide, and the reverse movement not only closes the valve, but locks it tightly upon its seat, thereby preventing all leakage.

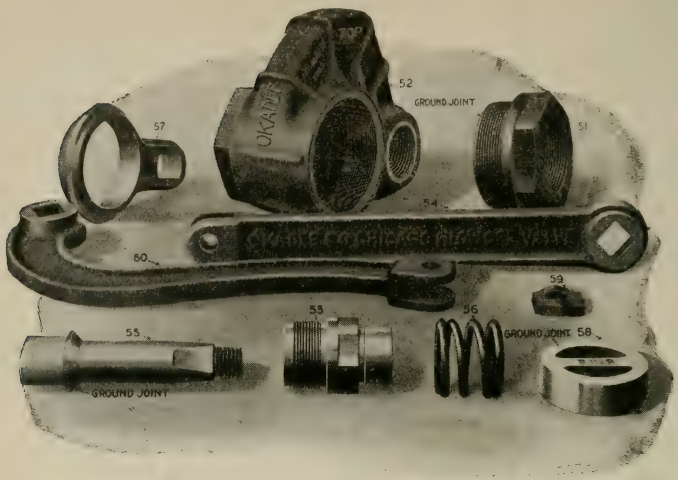
OKADEE BLOW OFF VALVE

The Okadee blow off valve is a "straight way," quick action, easy opening valve—no chance for anything to lodge in it. It can be reground without detaching valve body from boiler by simply removing the large hexagon nut, which has seat in its inner end, and bronze disc. These parts may then be taken to the bench for retouching of surfaces.



Okadee Blow Off Valve

This valve as shown in the illustration has no stuffing box. A 45-degree shoulder on inner end of tool steel stem forms a joint with the inner end of the bronze stem bushing. These valves are tested to 500 lbs. per square inch hydraulic pressure.



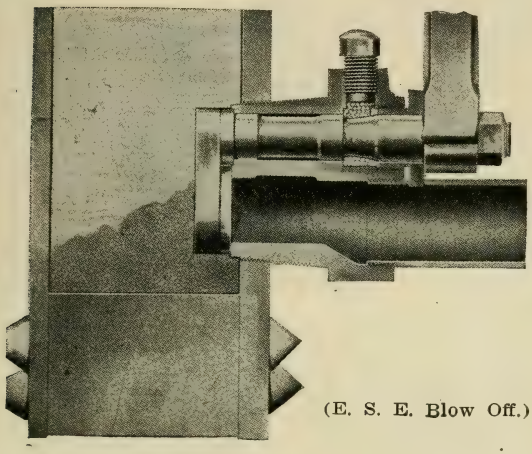
Parts of "Okadee" Blow Off Valve

51. Hexagon Nut with seat on inner end.
52. Main Body, One Piece.
53. Bronze Stem Bushing.
54. Operating Handle.
55. Forged Steel Stem.
57. Disc Carrier.
58. Gun-Metal Bronze Disc.

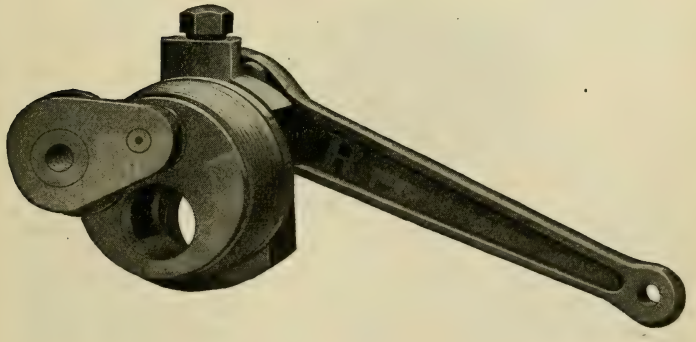
THE E. S. E. BLOW-OFF VALVE

The accompanying illustration shows the application of the E. S. E. blow-off valve to the water leg of a boiler just above the mud ring. The valve, being inside, the boiler cannot freeze in the coldest weather nor be prevented from closing by scale and sediment. The solid brass body screws into the boiler and the valve spindle is packed by lead shot and graphite. The only repairs ordinarily required can be made by facing off the valve disc and seat. This valve provides a clear and unrestricted opening straight through so that scale, rivets, stay bolts, etc., should they get into the valve, will pass beyond the valve seat and avoid its failure

to close. The valve handle is usually connected by a rod to an operating lever in the cab, on either side, so as to be easily operated by the engineer and the fireman.



(E. S. E. Blow Off.)

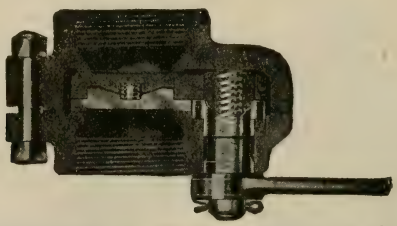


EVERLASTING BLOW-OFF COCK

The Everlasting has two seats, one in each bonnet of the valve, and the spring between the discs closes the ports in both bonnets, shutting out the dirt until opened; also, pivots the valve disc and holds the valve tight when steam

pressure on the boiler is down, taking care of back pressure perfectly.

The inlet orifice is tapered just above the seat, which increases the velocity of the blast at this point and insures its delivery into the discharge pipe without impairment of



the seat, and also has the effect of syphoning the valve clean at each operation.

Two types of valves are made—the Standard type and the Texas type. The Texas type valve is equipped with special fittings to resist galvanic action, caused where alkali is in the water.

AUTOMATIC AIR AND STEAM COUPLER.

The illustrations here given show a device that automatically couples and uncouples the air brake pipes on freight trains, and the air signal and steam heating pipes as well on passenger trains. This device has been in successful operation on a number of passenger and freight trains. Figs. 1 and 2 show a plan and a side view of the device.

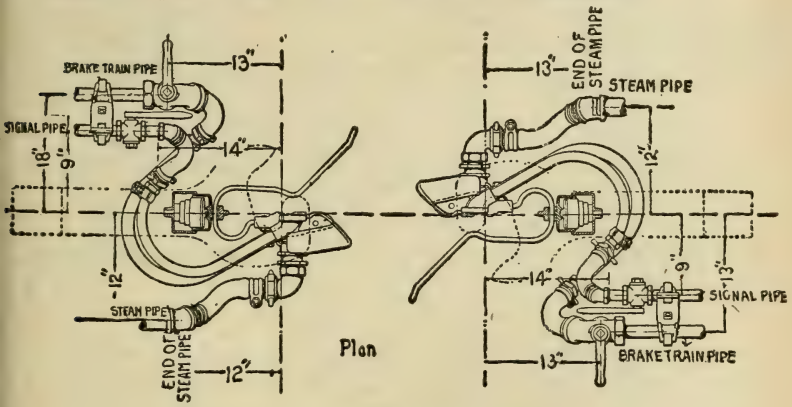
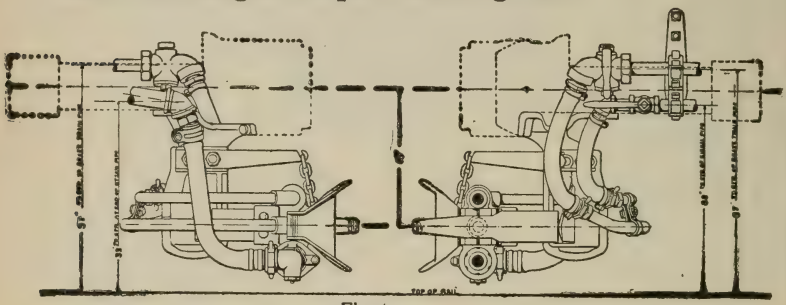


FIG. 1.
Automatic Air and Steam Coupler.

The construction, manner of attaching and operation of this device may be described as follows: The apparatus is interchangeable, there being no rights and lefts. The coupling head consists of a casting with openings on its face to receive the registering gaskets, and a coupling spring riveted thereto, as shown on the plan view (Fig. 1). On the elevation

view (Fig. 2) is shown a cast-steel bracket riveted to the under side of the drawbar, to which a slotted hanger, in which the coupling spring rests, and a chain arm to support the coupling head, are bolted.

The gaskets are so placed in the head that neither is touched by the opposite one until the coupling is made. This protection is effected by a tongue and groove, on which tongue the face rides until the gaskets are in position to register, when the tongue drops into the groove.



Elevation.

Fig. 2.

Automatic Air and Steam Coupler.

The outer end of the coupling head, having "V" and wedge-shape guides, is directed both vertically and horizontally by the outwardly bent spring on the opposing members. This coupling spring performs the double function of guide and clamp to hold the head firmly together when coupled.

As will be seen on the elevation views, the heads are tapped to receive the air pipes to which connection is made to the train and signal pipes by a short hose.

The steam attachment is so arranged that it can

be readily removed or attached without affecting the air connections. An automatic drip at the lowest point of the steam attachment provides for all condensation.

As will be seen on the plan views, the slotted hanger is provided with a spring buffer which positively insures the air coupling under all conditions where the car couplers will operate, and which maintains the coupling point of the air coupler in advance of the car coupling. The spring resting in this slotted hanger, the head being suspended by the chain, and the flexibility of the short hose permit the free movements required by the variations in the heights of cars, as well as the movements on curves, and also permit the free coupling in all such cases.

An interchange is provided in such a way that coupling may be effected with the ordinary hand hose coupler.

The coupling and uncoupling takes place automatically and simultaneously, as well as with the same degree of certainty, as does the car coupling.

THE LINSTROM SYPHON PIPE.

This is a decided improvement over the old form of tank valve which too frequently becomes disconnected from the spindle, requiring the draining of the tank and reconnecting.

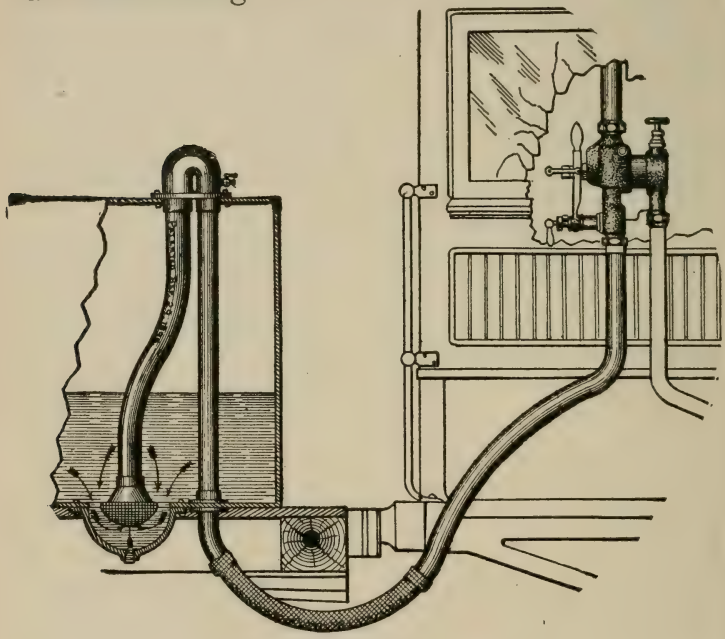


FIG. 1.
Linstrom Non-Freezing Syphon Pipe.

The syphon is said to be more easily and cheaply applied than the ordinary tank valve and hose strainer, with which it does away. With this device

there can be no flooding of the gangway by the leakage of the tank valve which is, of course, dangerous in cold weather.

As soon as the injector is started the priming fills the syphon, which remains full. It is impossible for the hose to freeze, for by simply permitting the injector to blow steam back into the tender the hose and feed pipe are immediately emptied of water, leaving nothing in the exposed pipe or hose to freeze.

To clean any sediment from the tank, remove the small plug in the bowl shown below the strainer. To disconnect the tank hose when there is no steam to blow the water out of feed pipe, open the small pet cock shown at the top (or return bend), thereby admitting air and breaking the action of the syphon. This air cock should be closed at all times when working the syphon.

This device also permits the use of a large strainer with small openings.

LOCOMOTIVE FEED-WATER STRAINERS.

THE SELLERS' STRAINER.

The Sellers' strainer, herewith illustrated, from long continued service has shown many special advantages to recommend it.

The strainer has standard pipe and hose connections, and is coupled directly to the end of the injector suction pipe. It occupies but little more space than the ordinary hose nut and cone strainer, and can be usually applied without alteration of the length of

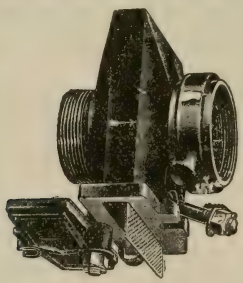


FIG. 1.
View of Strainer from Under Side showing Straining Plate Partially Removed.

the hose or of the pipe. The metal straining plate is of large area, and is provided with holes so small that fine particles, which pass through the ordinary strainer, are excluded from the injector; the dirt trap is large and admits of a considerable accumulation before cleaning is required; among other advantages claimed are the certainty of a continuous and plentiful supply of water to the injector, less wear of the

injector combining and delivery tubes, a considerable saving of time over the ordinary method in removing and cleaning the strainer, and a convenient and mechanical arrangement of all the parts.

This strainer can be cleaned in a few minutes without breaking the pipe or hose joints. Fig. 1 gives a view from the under side, with the nuts slackened, the T-head bolt swung upward, the cap

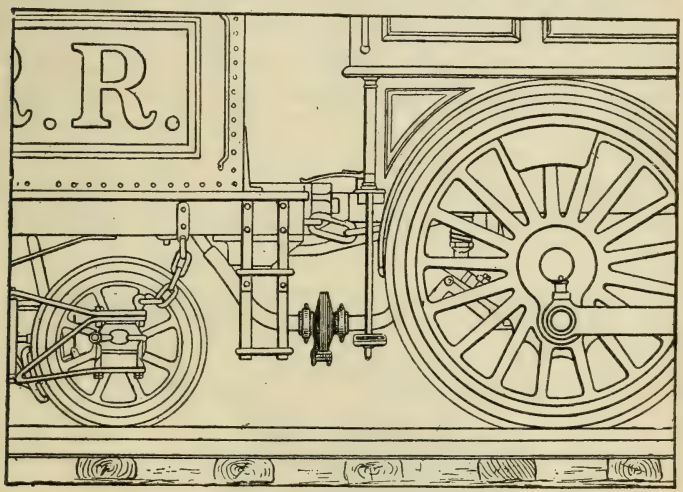


FIG. 2.
Position of Strainer on Locomotive.

rotated on the fixed stud clear of the opening, and the straining plate partially removed. The ends of both bolts are provided with split pins to prevent the complete removal or accidental loss of the attaching nuts and washers. All other parts are made of strong brass, the strainer plate being of copper. An arrow on the side of the strainer body indicates the direction

of the flow of water. This strainer may be used without change on either the right or the left side, and is adapted for use with any style of injector, and gives ample capacity for any size up to and including No. 12.

HEATH FEED-WATER STRAINER.

Fig. 3 illustrates another convenient form of hose strainer. The strainer itself is of such shape and size as to permit of a large number of small perforations, giving ample opening and still excluding much dirt from the injector. The large drain cup below the strainer forms a pocket to catch cinders and sediment from the tank, which can be readily and quickly discharged by removing the plug at the bottom.

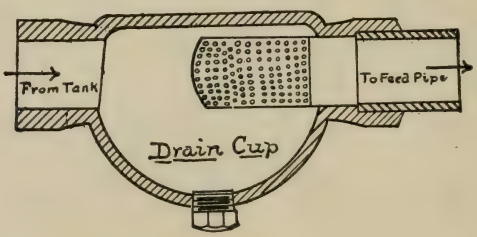


FIG. 3.
Heath Feed-Water Strainer.

H-D LOCOMOTIVE STRAINER.

The H-D locomotive strainer is an improved form of hose strainer giving full area, and can be used for either the right or left hand side of the locomotive. The screen is circular in form and rigidly attached to

the cap or bonnet, which forms a receptacle for all dirt and sediment. By removing the cap or bonnet the dirt or sediment is removed with the screen, which can easily be cleaned.

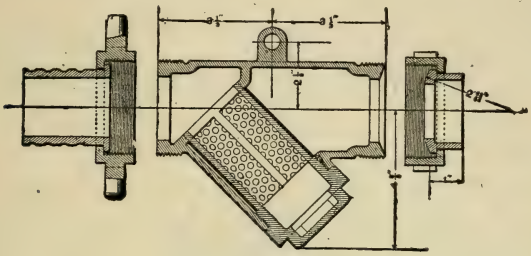


FIG. 4.
The H-D Locomotive Strainer.

THE HANCOCK LOCOMOTIVE HOSE STRAINER.

The hose strainer illustrated by Fig. 5 consists of a perforated copper plate in a metal frame which fits into slides in the body. The perforated copper plate

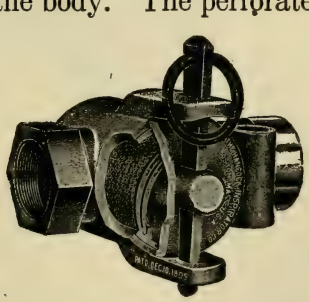


FIG. 5.
Hancock Hose Strainer.

rests at such an angle that coal or other sediment from the tank will drop below the plate and not interfere with the water-way. By removing the tapered

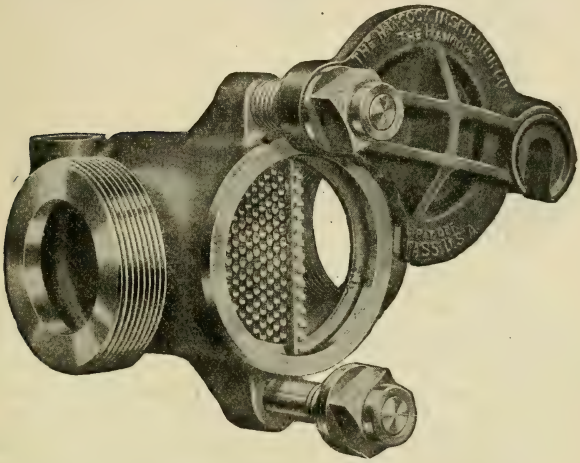
key, the bonnet or cap can be easily taken off and the copper plate removed and cleaned. The bonnet is fitted with a ground joint, and the seat is so located as to be protected from damage. This strainer is furnished either right or left hand.

The simplicity of its construction and its great convenience to locomotive engineers will readily be seen.

When it is considered that a large capacity injector suitable for large modern locomotive boilers delivers approximately one gallon of water each second, it will readily be seen why such importance is placed on having a good-sized, effective feed-pipe strainer that will not become quickly stopped, and when so deranged can be removed and cleaned without serious loss of time.

THE HANCOCK IMPROVED LOCOMOTIVE HOSE STRAINER

The locomotive hose strainer here shown, consists essentially of a perforated plate of ample area, mounted in grooves in the body. The opening through which the screen is introduced is closed by a cover, making a water-tight fit.



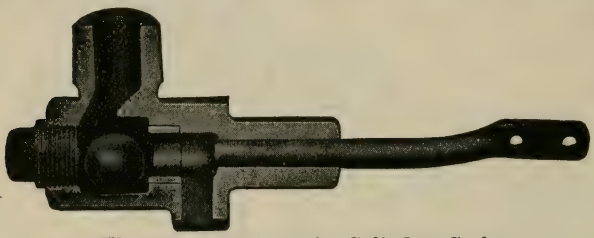
Hancock Improved Locomotive Hose Strainer.

The cover has a rubber gasket set into its inner side which engages a seat on the body, to which the cover is secured by stud bolts. The cover revolves on one bolt, on which it is spring mounted, and is held securely in place by the second bolt and nut, when closed.

This strainer can be used either right or left hand, with the inlet end blank or threaded to fit hose couplings in use, and with the suction or feed pipe end blank or fitted for iron or copper pipe.

WATERTOWN AUTOMATIC CYLINDER COCKS

The Watertown automatic cylinder cock is designed to automaticaly take care of the water of condensation and keep the cylinders dry at all times when the locomotive is standing still, and is opened and closed automatically without any attention from the engineer. A gun metal ball is held tightly against the Tobin Bronze seat at all times when the throttle is open and makes a tight joint free from any tendency to wear out of true and allow steam to escape. As soon as the throttle is closed this ball falls from its seat and allows all condensation to be drained from the cylinders



Watertown Automatic Cylinder Cock.

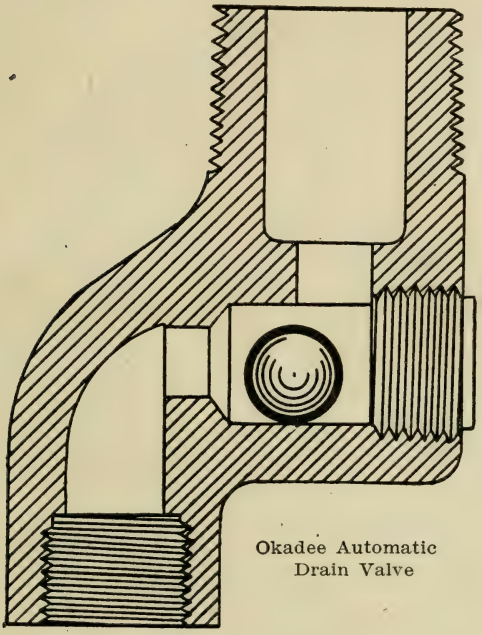
while the throttle remains closed; upon opening the throttle the steam pressure immediately raises the ball and forces it against its seat, making a steam-tight joint. In addition to the automatic feature auxiliary means are provided for opening cocks from the cab by the usual cylinder cock lever should the engineer desire to open them and hold them open against steam pressure. The cocks are so designed as to fit very closely to the cylinder and give from one to two inches more road clearance than most cocks now being built.

OKADEE AUTOMATIC DRAIN VALVE

This drain valve may be applied to the locomotive blower line, the steam line to the air pump, and to the cylinder cavities.

When steam passes through the line to which the Okadee automatic drain valve is attached, the pressure forces the steel ball against its seat and closes the drain valve, leaving the steam line free from condensation and preventing any leakage of steam through the valve. As soon as this pressure

is removed the steel ball is released and all condensation accumulating is drained, none remaining to be blown out through the stack with the steam the next time the line is operated.



Okadee Automatic Drain Valve

It prevents the condensation from being blown out of the stack, dirtying the engine and covering anyone standing nearby with dirty water.

It also prevents any condensation in the steam line to the air pump from destroying lubrication and packing rings, necessitating constant repacking.

It further prevents condensation from accumulating in the cylinder cavity and draining back into the cylinders, which sometimes causes the breaking or knocking out of cylinder heads.

SNOW FLANGER.

THE Q & C-PRIEST SNOW FLANGER.

This flanger is supported directly on the engine truck boxes, a few inches in front of the forward wheels. Being thus supported, it does not rise and fall with the movement of the engine on the springs, nor swing sideways across the rail on curves. This feature enables it to do regular and uniform work. As it follows the movement of the engine truck, it conforms to all the irregularities of the track, giving an even depth of cut, the same on curves as on tangents.

The knives are placed one inch above the top of the rail and make a cut twelve inches wide by two inches deep inside of the rails, and twelve inches wide and one-half inch deep outside of the rails.

While the knives are constructed strong enough to remove hard packed snow and sand, they are purposely designed so as to break when striking guard rails or any obstructions without damage to the other parts, and can be readily and quickly replaced.

This flanger is operated by compressed air by means of a cylinder located on or near the running board, and is under full control of the engineer by means of an air cock in the cab.

It may thus be raised instantly to clear crossings, guard rails, etc. There is also a hand lever arrangement running to the cab, so that the engineer may operateit by hand or hook it up out of use in case the air pump should fail.

It is claimed that torpedoes may be used with no

danger of their displacement by this flanger in operation through the hardest snow. It is further claimed that its use prevents derailments caused by engine truck wheels mounting hard packed snow or sand, and also prevents loss of hauling power of locomotives

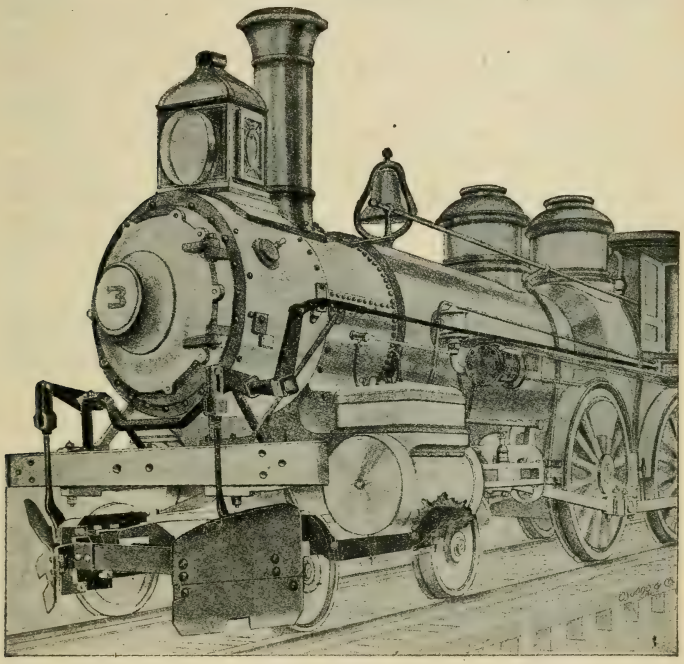


FIG. 1.
The Q & C-Priest Snow Flanger as Attached to Locomotive
(Pilot Removed to Show Working Parts of Flanger.)

caused by the intervention of snow and ice between the driving wheels and rails. It avoids tire and rail cutting due to slipping in snow.

A pilot plow of any size can be carried in the usual manner without interference with this device.

AUTOMATIC BRAKE-SLACK ADJUSTER.

While there have been many types of brake-slack adjusters used on cars and locomotive tenders, that adjuster formerly known as the McKee, but now made by the Westinghouse Co., and called by the latter name, has been used more extensively than any other.

The accompanying engraving shows a coach or tender brake cylinder and levers with the Westinghouse slack adjuster applied to the back head. As

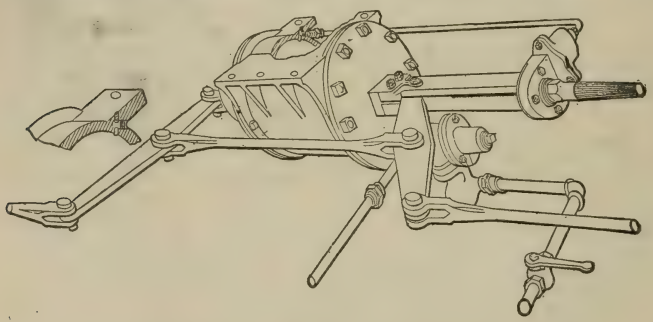


FIG. 1.
The Westinghouse Latest Improved Slack Adjuster.

will be seen, a very small air pipe is tapped into the brake cylinder at a point to clear the piston when the latter has traveled seven and one-half inches. Thus, when the brake piston passes beyond this point a small quantity of air is conveyed through this pipe to a very small cylinder wherein it forces a piston against a heavy spring engaging a pawl in a ratchet wheel attached to the screw holding the back cylinder

lever. When the brake is released, the spring, by means of the pawl and ratchet wheel, turns the screw, thereby moving outward the inside end of back cylinder lever, which takes up about one-thirty-second of an inch of piston travel. When new brake shoes are applied the screw should be turned back sufficiently to let out the travel to about what it was before the new shoe was applied.

The Gould slack adjuster is also a mechanical device which works, however, on the ratchet principle and without any use of the air pressure, as will clearly be seen by reference to the accompanying engraving.

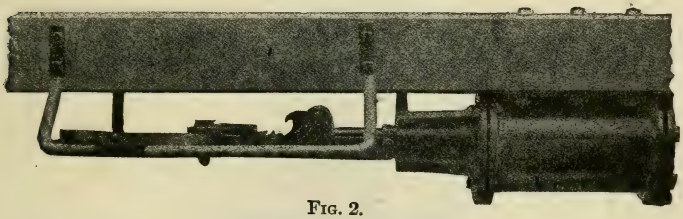


FIG. 2.
Gould Brake-Slack Adjuster.

The advantages to be gained by the application of any efficient brake-slack adjuster to cars or locomotive tenders are of considerable importance.

Their use will keep the piston travel of all the brake cylinders uniform, thus insuring maximum pressure of the brakes and permitting better stops to be made and preventing serious shocks which usually cause damage of some nature. Anything which tends toward the efficiency of the brakes reduces the waste of air and accordingly reduces the requirements placed upon the air pump, thereby lessening the cost of pump repairs.

LOCOMOTIVE GLOBE VALVES, RELIEF VALVES, ETC.

Fig. 1 shows the ordinary construction of either globe or angle valves for locomotive use. The particular valve here shown is designed for service where an all-metal valve is required, and is claimed to be especially adapted for high steam pressures and to withstand "wire drawing," being made with a flat

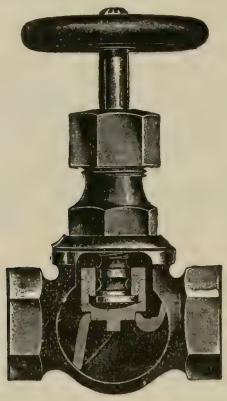


FIG. 1.
Standard Heavy Locomotive Globe Valve.

seat. The projection under the disc protects the seat from dirt and from the cutting action of the steam when the valve is partly open, and also serves as a guide when re-grinding is necessary.

To re-grind one of these valves, remove the disc from the stem and grind it with a temporary holder screwed into it.

THE CROSBY SPRING SEAT VALVE.

This valve is shown in Fig. 2, which represents the valve with a section of the body removed in order to show its internal design. *A* is the upper disc, in which *a a* represents the seat with its conical depression terminating in an annular groove of considerable depth. *C* shows the valve body, whereon at *b b*, in the valve seating *B*, is constructed a conical seat having in the center a similar

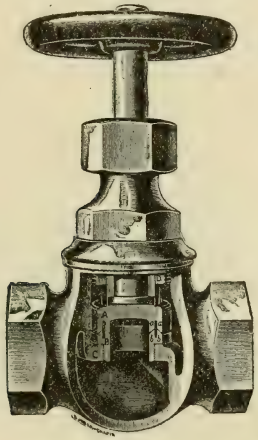


FIG. 2.
Crosby Spring-Seat Valve.

groove. These seats have greater contact surface, and by means of the central grooves have greater resilient action, which permits them to shut tight and remain so. This novel characteristic prevents them from jamming when the valve is closed, and leaves them free to accommodate themselves to any variation of temperature. When partially open, it is claimed that the out-rushing steam or water does not abrade

their surfaces, as ordinarily happens with ordinary valves.

THE HOMESTEAD STRAIGHT-WAY VALVE.

This valve is so constructed that when it is closed it is at the same time forced firmly to its seat. This result is secured by means of the traveling cam *A* through which the stem passes. The cam is prevented from turning with the stem by means of the lugs *B*, which move vertically in slots. Supposing the valve to be open, the cam will be in the lower part of the chamber in

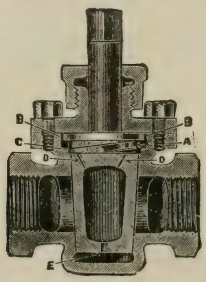
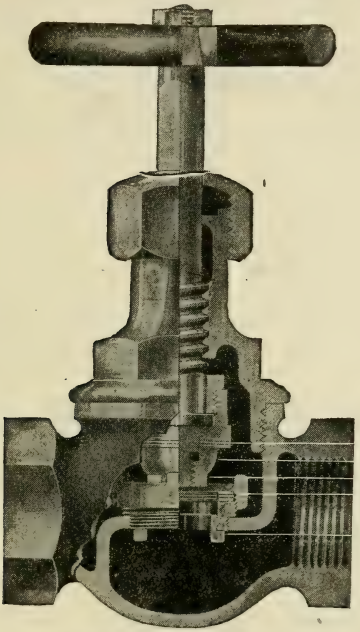


FIG 3
Homestead Straight-Way Valve.

which it is placed, and the plug will be free to be easily moved. A quarter of a turn in the direction for closing it causes the cam to rise and take a bearing on the upper surface of the chamber, and the only effect of further effort to turn the stem in that direction is to force the plug more firmly to its seat. A slight motion in the other direction immediately releases the cam and the plug turns easily, being arrested at its proper open position by contact of the fingers of the cam at the other end of its travel. *E*, *D*, *D*, are balancing parts. This valve forms a very efficient blow-off

valve where an automatic valve is not desirable (see chapter on Boiler Cleaners.)

THE MULTIPLATE VALVE



Multiplate Globe Valve.

The trade mark Multiplate means many plates and applies to the multiplicity of thin metal plates of rolled metal that compose the head and seat surfaces of the valves.

The plates are made of any metal best suited to the conditions of service to which the valves are applied, and are about the thickness of metal that would ordinarily be refaced or reground off the contacting parts of the valve surfaces ordinarily used, when they are worn from continuous service.

The plates are applied compactly together to the head and to the seat, forming a solid wearing surface to the parts, and produce with ease a tight metal seated valve.

When this wearing surface becomes worn or cut, a plate may be taken off the head of the valve, and one off the seat, and thrown away. The succeeding plate on each part will present a new true surface; this is all that is necessary to make a tight valve. This simple operation entirely eliminates refacing or regrinding, which is considered essential to the ordinary type of metal seated valves, and allows the use of the most expensive metal in the most economical form. The valve compensates for the discarding of the plates as they are used.

It is believed that metal seated valves are the only efficient mechanical proposition for high pressures and hard service, but when they become leaky, the absence of repair parts and the expense of such parts, together with the difficulty of regrinding has been their chief objection; hence this valve is intended to bring the metal seated valve back into use through its common sense method of applying thin metal plates to the head and seat of valves, to act as shields and protect the master seats.

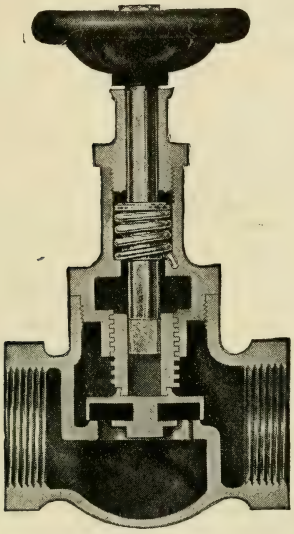
In case the magazine or repair parts or plates become exhausted, and others not being at hand, these same original or master seats will provide a valve equal to the best.

There can be no failure of any one repairing this valve who has even a limited mechanical knowledge; and the value of a valve depends upon the facility and economy with which it can be repaired.

Everyone who has had experience with valves that are used throttled or partly open, wire drawing the steam across the contacting seats of the valves knows it is hard service; also that where a valve is opened and shut hundreds of times a day it is a good test of the durability of a valve. It is in such service that the Multiplate system of valves has demonstrated its great worth.

SYRACUSE PACKLESS VALVE

Herewith is shown a cut of a valve that has not only the usual composition valve seat but also a second composition disc held against the valve stem and bonnet cap by a spring.



Sectional View of a Syracuse Packless High Pressure Valve.

This top disc also screws into the bonnet, forming a lock-nut feature that prevents its getting loose.

In case of renewals, this top disc can be replaced with pressure on the valve.

STEAM CHEST VACUUM VALVES.

The purpose of these valves is to permit air to enter the steam chest and thence the locomotive cylinder when the engine is "drifting" or running with steam shut off.

These valves are often termed "relief valves," but should more properly be known as *vacuum* relief

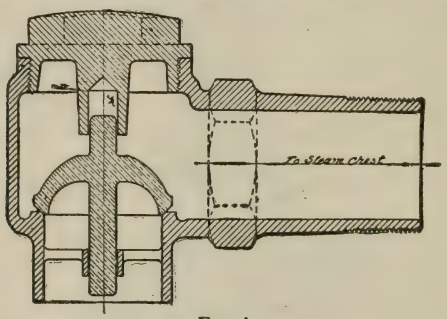


FIG. 4.
Steam Chest Vacuum or Air Relief Valve.

valves or suction valves, one type of which is shown in the engraving, Fig. 4.

Inasmuch as it is well known that the steam chest pressure may at times become very great when a locomotive at speed is reversed and the throttle not opened, many railroads use a combined *vacuum and pressure relief valve*, as shown in Fig. 7, on all steam chests. It is hardly necessary to describe in detail the pressure relief valve thus used, as its principle is identical with that of the locomotive pop safety valve, which is fully described and illustrated elsewhere in this volume. If, in place of the cap shown in the vacuum relief

valve here illustrated, a pop safety valve should be screwed, the result would be a combined vacuum and pressure relief steam-chest valve. The pressure spring is usually adjusted to an amount slightly in excess of the boiler pressure to avoid its blowing when the locomotive is working hard and under full pressure.

Two forms of *pressure relief valve* are shown in Figs. 4 and 5.

RICHARDSON RELIEF VALVE.

In order to obtain the best results from valves (especially balanced valves) on locomotives, a relief valve should be placed in the steam chests for the

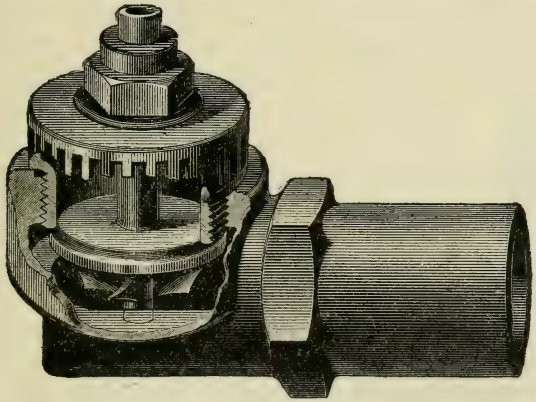


FIG. 5.
The Richardson Vacuum Relief Valve.

purpose of admitting clean air from the outside atmosphere, and thereby preventing a vacuum being formed in the steam chests and cylinders when the engine is running with steam shut off; otherwise air from the

smoke-box, charged with hot gases, dust and cinders, will be drawn into the chests and cylinders through the exhaust ports, burning up all oil and cutting and grinding the valves and valve seats.

The valve here shown by Fig. 5 can be used with much benefit with any slide valve. It is made extra heavy, to stand wear, and the curved valve wings are so arranged that the valve in closing always finds a new seat, thus keeping itself tight.

BLACKALL RELIEF VALVE, FOR USE ON LOCOMOTIVES.

This valve is placed on a locomotive at any point between the throttle valve and slide valve, preferably upon the steam chest, where it will have a free and open communication with the steam pipes of the engine only. It is designed to prevent the accumulation of pressure in the pipes or boiler of a locomotive if engine is suddenly reversed while moving forward, as is frequently the case. The valve is adjusted to open at a slightly higher pressure than the maximum pressure carried on the boiler, but below the pressure required to produce a rupture of parts, and will permit the excess of air pressure to escape from the steam pipes, and thereby prevent any undue pressure being generated by the cylinders. A uniform pressure of air will be maintained within the limit of safety, which will supply resistance to the pistons and overcome the momentum of the train, and perform the functions of an

FIG. 6. Blackall Relief Valve for Use on Locomotives.

automatic air brake on the drivers, and stop the train. By the use of this device engines can be reversed suddenly while running at a high rate of speed, without strain or damage to any portions of the machinery or boiler.

RICHARDSON COMBINED PRESSURE AND VACUUM RELIEF VALVE.

This valve (Fig. 7) is designed to be placed in the steam chest to automatically supply clean air to the cylinders through the air-valve *A* when engine is

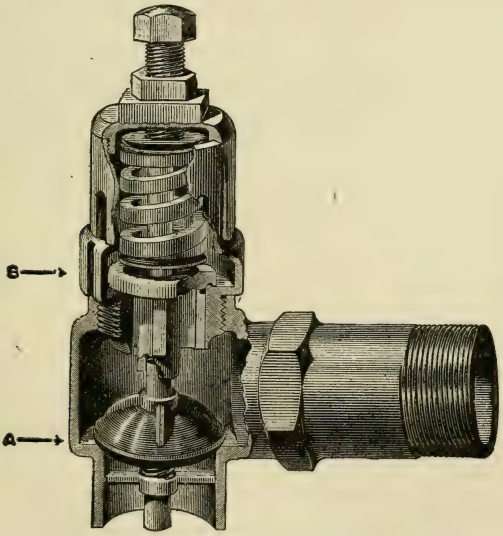


FIG. 7.
Richardson Combined Pressure and Vacuum Relief Valve.

running shut off, and thus furnishes a free supply of air from the outside instead of its being sucked in

from the smoke-box laden with hot gases and cinders which lap all oil from the valves and seats.

The pressure relief valve *B* performs a very valuable function in preventing the dangerous accumulation of pressure in the steam chest and dry-pipe and oftentimes the breaking of same when the engine is suddenly reversed. The valve is set to open at a pressure slightly above the maximum boiler pressure, and will allow any excess of pressure to escape to the atmosphere, yet will maintain in the cylinders a uniform pressure of air within the limits of safety when running forward after reversing, and thus supply resistance to the pistons and overcome the momentum of the train, and perform the functions of an automatic air brake in assisting to stop the train. By using this valve an engine may be suddenly reversed while running at high speed without strain or damage to any portion of the machinery or boiler.

LOCOMOTIVE BOILER COVERINGS.

The extent of heat losses occurring by radiation from a modern locomotive boiler under service conditions has long been a matter of speculation. There have been investigations to determine the radiation from pipes and other steam-heated surfaces, usually within buildings, but, until recently, there have been no tests which would disclose the effect of the air currents such as, at speed, circulate about the boiler of a locomotive.

From such service tests it has been determined that a perfectly bare boiler would lose about ten per cent. of the total power of the machine, which would amount to nearly one thousand dollars per year on a large high-pressure locomotive, but that by properly covering about two-thirds of the exposed surface of boiler and fire-box over sixty per cent. of this loss may be prevented.

Thus it would appear to be a matter not undeserving the attenion of practical railroad men to know that by this means alone over half a million dollars per year may be saved on a railway system having one thousand locomotives.

An eminent professor states that "the best insulating substance known is air confined in minute particles or cells, so that heat cannot be removed by convection." He also states that "no covering can equal or surpass that of perfectly still and stagnant air, and the value of most insulating substances

depends upon the power of holding minute quantities in such a manner that circulation cannot take place."

The covering used on a boiler is often termed lagging, from the custom when wood covering was used.

Wood lagging when first applied, and if the workmanship is good, is a good heat insulator; but it is quite impossible to obtain thoroughly dry lumber for this purpose, and the result is that after it has been subjected to the temperature of the boiler for a longer

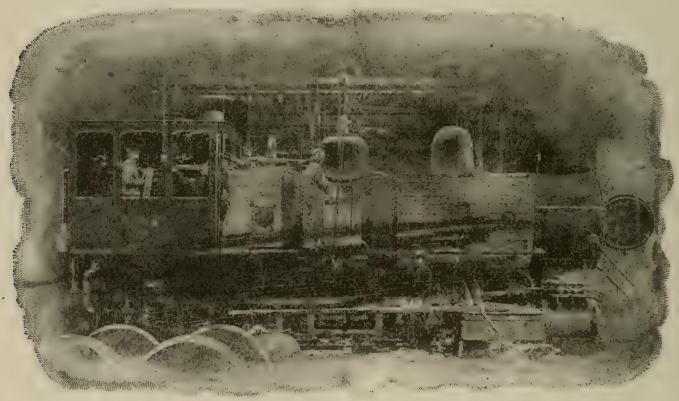


FIG. 1.
Manner of Covering a Locomotive Boiler with Sectional Lagging.

or shorter time the wood shrinks and the joints open, and the wood is charred and rattles from place and soon becomes of little use as an insulator. For this reason the use of wood lagging, long so universally practiced in this country, is being largely abandoned for other more fibrous material which does not warp and shrink, but retains its original form after continued use.

A large number of manufactured boiler coverings are composed in part or whole of asbestos or magnesia.

Asbestos is a fibrous mineral, and one of Nature's unique products. It is found in various parts of the world and usually occurs in narrow veins or seams. When treated mechanically it yields soft, white,

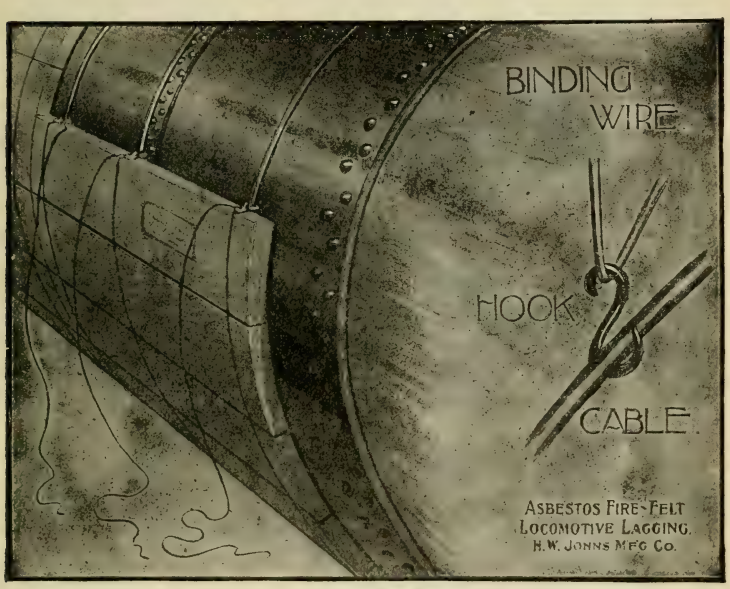


FIG. 2.
Method of Securing Sectional Lagging to the Boiler.

delicate and exceedingly strong fibres, which can be spun, woven and otherwise manufactured into many useful articles. In addition to its fire-proof qualities, it is also acid proof and practically indestructible except from abrasion.

Fig. 1 shows a locomotive boiler undergoing the process of covering with a form of manufactured

covering known as sectional lagging. From Fig 3 the details of its application may be readily understood.

When it is such general practice in stationary and marine engineering to cover every particle of exposed steam pipe it would seem much more important to do so on a rapidly moving locomotive where the resulting radiation is very much greater.

FIG. 3.
Asbestos Covering for Steam Pipes.

Asbestos covering, as shown in Fig. 3, for steam supply pipes to the air pump, train heating system, electric headlight, etc., is gradually but surely coming into use.

THE STEAM ENGINE INDICATOR.

The degree of excellence to which the locomotive and other steam engines has been brought is very largely due to the use of the indicator. A careful study and comparison of indicator diagrams taken under different speeds, pressures, and with various cut-offs furnishes the only means of showing the action of steam in the cylinder and of gaining a definite knowledge of the various changes of pressure that take place therein.

An indicator diagram is the result of two motions, namely: a horizontal movement of the paper in exact correspondence with the movement of the piston, and a vertical movement of the pencil in exact ratio to the pressure exerted in the cylinder of the engine. Consequently, it represents by its length the stroke of the engine on a reduced scale, and by its height at any point the pressure on the piston at a corresponding point in the stroke. The shape of the diagram depends altogether upon the manner in which the steam is admitted to and released from the cylinder of the engine. The variety of shapes given from different engines, and by the same engine under different circumstances, is almost endless, and it is in the intelligent and careful measurement of these that the true value of the indicator is found; and no locomotive or stationary engineer should be without a knowledge of the principles and uses of this ingenious device and able to properly read an indicator diagram.

A diagram shows the pressure acting on one side of the piston only during both the forward and return stroke, whereon all the changes of pressure may be properly located, studied and measured. To show the corresponding pressures on the other side of the piston, another diagram must be taken from the other end of the cylinder. When the three-way cock is used, the diagrams from both ends are usually taken on the same paper.

To obtain trustworthy results on high-speed engines, an indicator must have extreme lightness, a nice adjustment of all the moving parts and fine workmanship; to these indispensable qualities should be added simplicity of construction and convenience of manipulation.

THE CROSBY STEAM ENGINE INDICATOR.

This indicator is designed to meet the requirements of modern steam engineering practice. The high-speed system of construction in locomotives and steam engines which greatly prevails to-day renders the older type of indicator well-nigh useless. Many details which gave little trouble at low speeds cause errors under the present requirements which seriously affect the results.

Fig. 1 shows a general view of the Crosby indicator, while the illustration in Fig. 2 is a sectional view showing the design and arrangement of the parts.

Referring to Fig. 2, part 4 is the cylinder proper, in which the movement of the piston takes place. It is made of a special alloy, exactly suited to the varying temperatures to which it is subjected, and

secures to the piston the same freedom of movement with high pressure steam as with low; and as its bottom end is free and out of contact with all other parts, its longitudinal expansion or contraction is unimpeded and no distortion can possibly take place.

Between the parts 4 and 5 is an annular chamber, which serves as a steam jacket; it will always be filled with steam of nearly the same temperature as that in the cylinder.

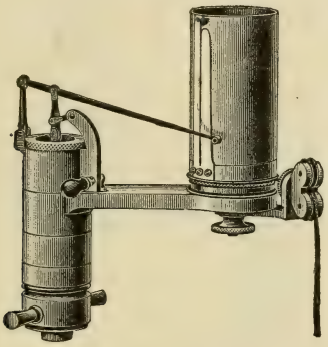


FIG. 1.
The Crosby Indicator.

The piston 8 is formed from a solid piece of the finest tool steel. Its shell is made as thin as possible consistent with proper strength. It is hardened to prevent any reduction of its area by wearing, then ground and lapped to fit (to the ten-thousandth part of an inch) a cylindrical gauge of standard size. Shallow channels in its outer surface provide a steam packing, and the moisture and oil which they retain act as lubricants and prevent undue leakage by the piston. The transverse web near its center supports a central

socket, which projects both upward and downward; the upper part is threaded inside to receive the lower end of the piston rod; the upper edge of this socket is formed to fit nicely into a circular channel in the under side of the shoulder of the piston-rod when they are properly connected. It has a longitudinal slot which permits the ball bearing on the end of the spring to drop to a concave bearing in the upper end of the piston screw 9 which is closely threaded into

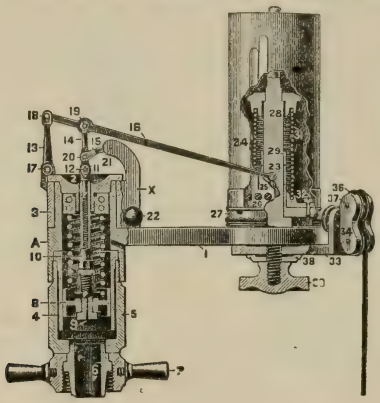


FIG. 2.
The Crosby Indicator.
(Sectional View.)

the lower part of the socket; the head of this screw is hexagonal and may be turned with the hollow wrench which accompanies the indicator.

The piston rod 10 is of steel, and is made hollow for lightness. Its lower end is threaded to screw into the upper socket of the piston. Above the threaded portion is a shoulder having in its under side a circular channel formed to receive the upper edge of the socket when these parts are connected together. When

making this connection the piston rod should be screwed into the socket as far as it will go; that is, until the upper edge of the socket is brought firmly against the bottom of the channel in the piston rod. This is very important, as it insures a correct alignment of the parts and a free movement of the piston within the cylinder.

The swivel head 11 is threaded on its lower half to screw into the piston rod more or less, according to the required height of the atmospheric line on the diagram. Its head is pivoted to the piston rod link of the pencil mechanism.

The cap 2 screws into the top of the cylinder and holds the sleeve and all connected parts in place. Its central hole is furnished with a hardened steel bushing which forms a durable and sure guide to the piston rod. On its under side are two threaded portions. The lower and smaller projection is screw-threaded outside to engage with the like threads in the head of the spring and hold it firmly in place. The upper and larger projection is screw-threaded on its lower half to engage with the light threads inside the cylinder; the upper half of this larger projection—being the smooth, vertical portion—is accurately fitted into a corresponding recess in the top of the cylinder, and forms thereby a guide by which all the moving parts are adjusted and kept in correct alignment, which is very important, and is impossible to secure by the use of screw threads alone.

The sleeve 3 surrounds the upper part of the cylinder and supports the pencil mechanism. It turns around freely, and is held in place by the cap. The handle for adjusting the pencil point is threaded

through the arm and in contact with a stop-screw in the plate 1 may be delicately adjusted to the surface of the paper on the drum. It is made of hard wood, in two sections; the inner one may be used as a lock-nut to maintain the adjustment.

The pencil mechanism is designed to afford sufficient strength and steadiness of movement with the utmost lightness, thereby eliminating as far as possible the effect of momentum, which is especially troublesome in high speed work. Its fundamental kinematic principle is that of the pantograph. The fulcrum of the mechanism as a whole, the point of attachment to the piston rod and the pencil point are always in a straight line. This gives to the pencil point a movement exactly parallel with that of the piston. The movement of the spring throughout its range bears a constant ratio to the force applied and the amount of this movement is multiplied six times at the pencil point.

Springs.—In order to obtain a correct diagram, the movement of the pencil of the indicator must be exactly proportional to the pressure per square inch on the piston of the steam engine at every point of the stroke; and the velocity of the surface of the drum must bear at every instant a constant ratio to the velocity of the piston. These two essential conditions have been attained to a great degree of exactness in the Crosby indicator by a very ingenious construction and nice adaptation of both its piston and drum springs.

The piston spring is of unique and ingenious design, being made of a single piece of the finest spring steel wire, wound from the middle into a double

coil, the spiral ends of which are screwed into a brass head having four radial wings with spirally drilled holes to receive and hold them securely in place.

Adjustment is made by screwing them into the head more or less until exactly the right strength of spring is obtained, when they are there firmly fixed. At the bottom of the spring—in which lightness is of great importance, it being the part subject to the greatest movement—is a small steel bead firmly attached to the wire. This reduces the inertia and momentum at this point to a minimum, whereby a great improvement is effected. This bead has its bearing in the center of the piston, and in connection with the lower end of the piston rod and the upper end of the piston screw 9 (both of which are concaved to fit), it forms a ball and socket joint which allows the spring to yield to pressure from any direction without causing the piston to bind in the cylinder, which is liable to occur when the spring and piston are rigidly united.

The testing of the spring.—The rating or measurement of the springs is determined with great care and accuracy by special apparatus. The pressure test is made by the direct action of the steam in the cylinder of the indicator and in a mercury column, simultaneously operating with a capacity of three hundred pounds pressure per square inch. Suitable and ingenious electrical apparatus is so combined with these mercury columns that the ordinary division in inches of vacuum and in pounds pressure, respectively, are automatically marked on the test card on the indicator drum as the test of the spring proceeds. Each spring is tested in pressure to twice the capacity

marked on the same. This method of testing pressure springs has been in use for several years and has been demonstrated to be the best system for accuracy.

The drum spring 31 is a short spiral spring, thus greatly reducing the frictional resistance.

If the conditions under which the drum spring operates be considered, it will readily be seen that at the beginning of the stroke, when the cord has all the resistance of the drum and spring to overcome, the latter should offer less resistance than at any other time; in the beginning of the stroke in the opposite direction, however, when the spring has to overcome the inertia and friction of the drum, its energy or recoil should be greatest.

This drum spring, being a short spiral having no friction, has a quick recoil. At the beginning of the forward stroke it offers to the cord only a very slight resistance, which gradually increases by compression until at the end its maximum is reached. At the beginning of the stroke in the other direction its strength and recoil are greatest at the moment when both are most needed, and gradually decrease until the minimum is reached at the end of the stroke. Thus, a nearly uniform stress on the cord is maintained throughout each revolution of the engine.

The drum 24 and its appurtenances, except the drum spring, are similar in design and function to like parts of other indicators and need not be particularly described. All the moving parts are designed to secure sufficient strength with the utmost lightness, by which the effect of inertia and momentum is reduced to the least possible amount.

The Crosby indicator is made with a drum one and

one-half inches in diameter, this being the correct size for high speed work, and answering equally well for low speeds. If, however, the indicator is to be used only for low speeds and a longer diagram is preferred, it can be furnished with a two-inch drum.

All improved Crosby indicators are changeable from right-hand to left-hand instruments, if occasion requires.

TABOR INDICATORS

The cylinder of the Tabor Indicator is designed with an inner and outer shell, making it possible to replace the inner or wearing parts without distributing the latter. The inner shell is of a special hard bronze which will resist wear and

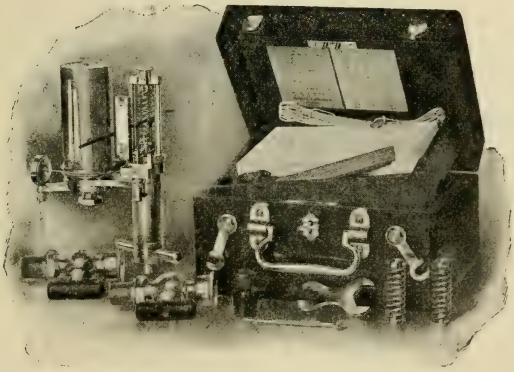


Fig. 1.
Tabor Indicator Outfit—Outside Springs.

give maximum service. It can be very easily renewed, when necessary. The special bronze shell makes, with the steel piston, an ideal combination giving, under all conditions, the proper fit to reduce friction to a minimum and, at the same

time, eliminate any inaccuracy resulting from an undue quantity of steam escaping by the piston. The coefficients of expansion of the steel of the piston and the bronze of the inner shell of the cylinder, together with their designs, prevent binding or excessive friction, experienced under high temperatures where bronze is employed for both of these parts. In the Tabor, the inside cylinder is steam jacketed which reduces, to a minimum, radiation and resultant condensation

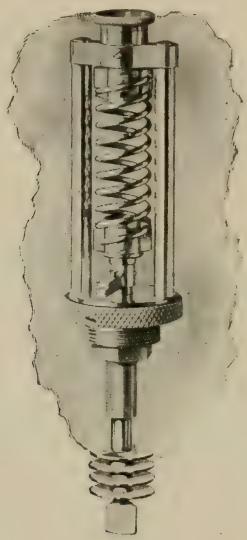


Fig. 2.
Piston and Outside Spring.

and pressure drop. This aids materially in reproducing in the indicator cylinder the exact pressure conditions prevailing in the engine cylinder. An adjustable sleeve is fitted on the outer cylinder, by means of which, the exhaust steam vents can be turned in any desired direction to deflect the steam away from the operator. The lower end of the outer cylinder is provided with a taper plug and coupling making a steam-tight joint for connecting the indicator.

The Piston is so designed as to have the effect of four separate pistons with deep sections between. When in operation, these sections fill with condensation and oil, resulting in perfect lubrication. With this design of piston, dirt, grit and other foreign substances, encountered in new engines, are removed from the surface of the indicator cylinder and stored in the sections between the plates of the piston, thereby eliminating the liability to clog and fail to operate as will the cylindrical form of piston, under these conditions. The

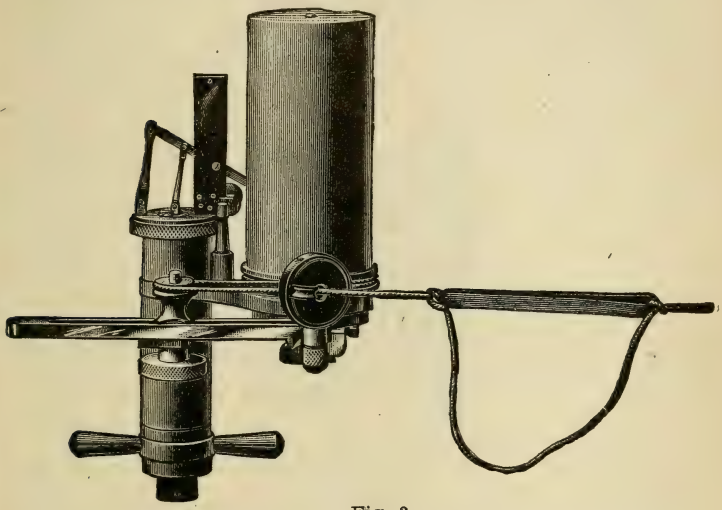


Fig. 3.
Tabor Indicator Fitted with Drum Stop Attachment.

standard piston for the Tabor Indicator is ½ square inch in area. For gas engine or other work, where pressures are higher than 325 pounds, the ¼-square-inch area piston is recommended.

The Springs for the Tabor Indicator are of the Duplex type being formed by two coils of wire attached, directly opposite each other to two threaded composition connections. These two coils are wound so that they have the same pitch. This

arrangement eliminates tendencies of the piston to cock, or bind, such as is liable where the single coil springs are employed. With a Tabor Spring friction of the piston is reduced to an absolute minimum and greater accuracy is acquired. The employment of two wires in the Tabor Spring divides the strain, materially increasing the life of the spring. There are no sharp turns or angles in the formation of the two coils and all strains are, therefore, evenly divided throughout. The wire in the springs of the Tabor Indicator is very carefully selected from the best spring material which can be secured for this purpose. This material is uniformly tempered and tested and has a very high elastic limit. Each denomination of spring is of a length which automatically fixes the Atmos-

Fig. 4.
Tabor Springs.

phere Line in the proper location on the card. This arrangement does away with any adjustment of the Atmosphere Line and eliminates a certain amount of lost motion which may take place in the adjusting mechanism. It also prevents the breakage of pencil arms and other parts which are liable to occur in certain designs.

There is also an outside connected spring instrument as shown in Fig. 1. In designing the Tabor Indicator with outside connected spring, all the best points of the inside spring design, that could be employed in the improved instrument, were retained. Under high temperature steam and gas engine

work, the outside spring instrument is a decided advantage over the older form of inside spring design. In the Outside Spring Type the spring is not subjected to the deteriorating temperature effect as is the case with the inside spring instrument. Greater accuracy and durability of spring is, therefore, attained. The Tabor Indicator with outside connected spring is more conveniently operated than the older form of inside spring instruments and other outside spring designs. The spring can be changed easily and quickly without handling highly heated parts. This is one advantage which will appeal to operators of indicators, where frequent changes of the spring are necessary.

The springs used in these two types of indicators differ only in that the springs for the outside spring instruments are made for service under atmospheric temperatures, while springs for the inside spring design are made for temperatures corresponding to the steam pressures, for which each individual spring is designed and adapted. It is well to consider that any inaccuracy in the spring or in the pencil mechanism is multiplied several times on the indicator diagram; therefore springs cannot be too reliable and too much care cannot be exercised to eliminate lost motion. All springs for use in Tabor Indicators with outside connected springs are marked D, while those for the Tabor Indicators with inside connected springs are marked T.

The Parallel Motion of the Tabor Indicator is constructed on an entirely different principle from all other designs and is accurate under all conditions and throughout all parts of the stroke. It consists of a vertical plate which is secured, in an upright position, to the steam cylinder. In this plate is a curved slot in which works a roller revolving on a pin set in the pencil bar. The design of the slot and the location of the roller on the pencil bar exactly compensate for the tendency of the pencil to move in an arc and results in a travel of pencil point exactly parallel to that of the piston. Furthermore, the ratio between the travel of these two parts is absolutely maintained throughout their entire range. By this design, friction is reduced to an absolute minimum and extreme accuracy is acquired. All parts of the Tabor Parallel

Motion are of the best milled steel, especially treated and blued, making them more satisfactory than parts which are of stamped steel. The design of materials employed in the Tabor Parallel Motion make for great strength. At the same time, inertia is reduced to a negligible quantity.

A Stop Device which prevents the pencil or recording point pressing too hard against the card, is provided. With this is furnished a small wooden handle which will remain cool under all conditions. A winged check nut is furnished in connection with this device for the close adjustment of the recording point.

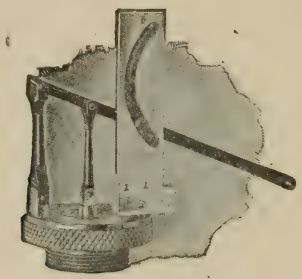


Fig. 5.
Parallel Motion—Tabor Indicator.

The Paper Drum in the Tabor Indicator is of the most modern type, being strong and at the same time very light, which eliminates inertia effects to the greatest extent. It is provided with two clips of different lengths which enable the operator to very quickly attach or remove the cards. The standard drum of the Tabor Indicator is 4 inches high and has a diameter of 2.03 inches giving a possible length of card of 5.25 inches. Where specified, a small drum will be furnished. This drum is 2.875 inches high and has a diameter of 1.5 inches and gives a possible length of card 3.75 inches. In the standard drum instrument, the pencil has a movement of 3.00 while with the smaller drum, the pencil motion is limited to 2.35 inches. The ratio of travel between the pencil point and piston is 5 to 1 in both the outside and inside

spring indicators with either size drum. The drum spring is of a design which practically maintains a constant tension on the drum carriage throughout all parts of the stroke, giving a smoothness and uniformity of action which insures the most accurate results. The tension of the drum spring may be varied to suit conditions of high or low speed engines, although the one setting is suitable for a large range of speeds. This spring is very durable and will hold its tension for long periods.

A Detent Motion is regularly supplied with all Tabor Indicators except instruments which are equipped with the Houghtaling Reducing Motion in which is incorporated a Detent Motion. By the Detent Motion the drum can be stopped

Fig. 6.
Slack Cord Take-Up.

for the insertion of a new card, without disconnecting the cord from the engine crosshead. This mechanism consists of a handle operated pawl which engages a ratchet on the drum carriage. When the Detent Motion is employed a convenient method of taking up the slack cord is found in the introduction of a rubber band as shown in the accompanying illustration, Fig. 6. This band must be of sufficient strength and length to take up all slack in the cord, which slack is equal to the stroke of the drum. This arrangement shown in the accompanying view, will prevent breakage of the cord when the drum is stopped. When this takes place, the rubber band contracts, taking up all slack between the points where it is knotted to the cord.

The Cord Guide Pulley of the Tabor Indicator permits the cord to be led off in any direction. After being adjusted it can be securely locked in position. The adjustment prevents breakage of cord, due to its catching in the pulley or

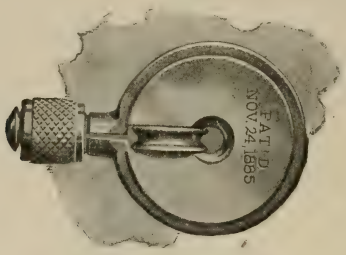


Fig. 7.
Cord Guide Pulley—Tabor Indicator.

other parts. Likewise the base on which the Cord Guide Pulley is mounted can be moved to any position in a horizontal plane and rigidly secured. The two adjustments in this pulley give a flexibility which is of great value in practical operation.

Fig. 8.
Connection to Crosshead.

Connection to the Engine Crosshead is readily made by means of a properly designed Hook engaging a liberal sized hole in a Flat Cord-adjuster, which is cord-attached to the crosshead or its reducing motion. At least two turns of cord should be wound on the indicator drum. The hook is connected to a loop, while the other section of the cord, which is

secured to the reducing mechanism or crosshead, is passed through the Flat Cord-adjuster, as shown in the cut. The freedom from knots admits of quick and close adjustment of the cord to the length required for proper running. This arrangement provides a simple means of connection, which will be found much easier to handle than where the hook is put through a loop in the cord.

Electric Attachment.— In making complete and reliable tests of steam power from any and all classes of engines, wherever it is necessary to use two or more indicators for the purpose, it requires some convenient and rapid means of operating them so that all cards taken at any particular stroke of the engine will commence and leave off in the same interval of time. The cut represents a simple electrical attachment as it is applied to the Tabor indicator for this purpose to enable the operator to produce diagrams from one or more indicators simultaneously during the same stroke of the engines, and from any number of cylinders by simply pressing a button arranged to close the electrical circuit.

The attachment consists of a magnet support *S*, which is clamped to the body of the indicator and held in place by the set-screw *E*. A magnet *M* is secured to the support, also binding screws *C* and spring *D*. An armature *A* is mounted on the rod *B*, and adjusted to coincide with the magnet *M*, and then secured to the rod *B* by the small set-screw in the armature for that purpose. The rod *B* is screwed into the upright on the swivel plate of the indicator, and any movement of the armature *A* produces a similar movement of the pencil toward or from the paper drum. The spring *D* is for the purpose of holding the armature within the field of the magnet before the current is established, and also to quickly release it when the current from the battery is broken.

The improved device is easily attached to or detached from the indicator in a few seconds. By removing the cap that supports the pencil movement of the indicator and

slackening the set-screw *E* of the support *S*, the attachment is readily removed. Its connection with the indicator does not in any way interfere with the usual speedy and convenient means of adjusting the diagram paper to, or removing it from, the paper holding drum, or the changing of a spring

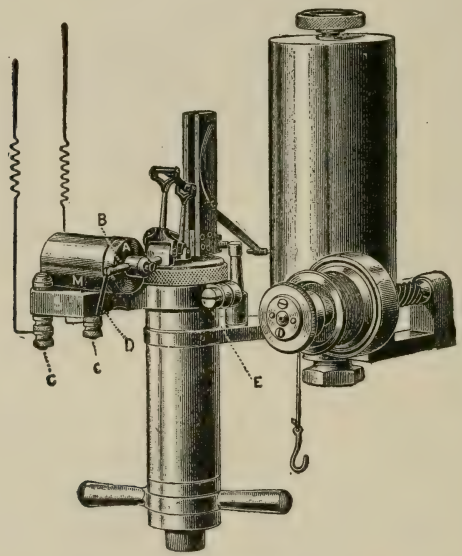


FIG. 3.

Tabor Indicator Fitted with Houghtaling Reducing **Motion** and Electric Attachment.

in the instrument. It can be used on either right-hand or left-hand indicators with equal facility by reversing the magnet support *S* and the magnet *M*, the latter being secured to its supporting shelf by two small screws. Any one of the well-known batteries in the market (either dry or liquid) will be ample to operate a single indicator where the circuit is short.

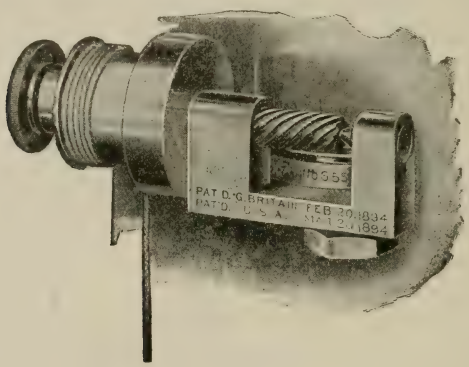
Houghtaling Reducing Motion:—To reduce the engine stroke to a length within the limits of the indicator drum, a reducing motion of some character is essential. The Houghtaling Reducing Motion is now the standard for the Tabor Indicator.

The Houghtaling Reducing Motion is composed of a supporting base piece, provided with short standards that form bearings for the worm shaft on which the flanged pulley is rotated, the outer bearing being a pivot which receives the entire thrust of the shaft, friction being thus reduced to a minimum. It is connected directly to the indicator upon the projecting arm that supports the paper drum and the worm shaft directly engages a gear on the drum carriage. Connected with the base piece is a spring case, containing a special spiral steel spring, the function of which is to return the pulley to its starting point, after it has been revolved in one direction by the forward movement of the engine crosshead. On the extreme end of the worm shaft is secured a collar through which freely slides a clutch pin, one end of which is securely fastened to a swivel thumb-piece for operating it. The Pulley runs freely and independently on the worm shaft and has, on its outside, a clutch-shaped hub. To this pulley is connected the actuating cord from the crosshead, which cord should encircle the pulley a sufficient number of times to have its length, when unwound, a little more than equal to the length of the engine stroke. The other end of the cord may be secured to the crosshead of the engine, to a standard bolted thereto or any moving part that has an exactly corresponding motion. The cord must be connected in a direct line from the pulley.

The pulley is independently rotated back and forth on the worm shaft, thereby making it unnecessary to unhook the cord from the crosshead when cards are to be inserted on the paper drum. The paper drum is rotated forward by means of the pulley through its worm shaft engaging the worm gear on the paper drum carriage, and in the reverse direction, by the action of its own spring. On top of the paper drum is a knurled thumb-piece made with a projecting pin on its

under side, which engages a similar pin located in the top of the drum. This thumb-piece is employed by the operator for moving the paper drum slightly forward before engaging the clutch on the Reducing Motion, preparatory to taking a diagram. This prevents the drum from striking against its stop on the return motion. This thumb-piece is also used to arrest the drum on its return motion, thereby disengaging the clutch and permanently stopping the paper drum.

The manner of operating the Houghtaling Reducing Motion, is to first select a pulley, the diameter of which is about one-twelfth of the length of the engine stroke.



Houghtaling Reducing Motion.

This pulley is placed upon the worm shaft, by first removing the clutch and then sliding the pulley on to the shaft, being careful that the small hole in the pulley engages the projecting pin in the cover of the spring case. Then replace the clutch on the shaft so that the set screw bears on the slabbed side of the shaft.

The indicator is then placed on the engine in such a position that the axis of the pulley will be perpendicular to the motion of the crosshead. The loose end of the cord is then run out to a distance of at least twelve inches beyond the

extreme forward travel of the crosshead. With the cord in this position, two turns should still remain on the pulley. While holding the cord, allow it to gradually rewind itself on the pulley until its loose end has reached a point coincident with the extreme backward travel of the crosshead. If only a slight tension of the cord exists at this point, it will be sufficient. The cord is then attached to the selected point on the crosshead or other point decided on. The cord tension may always be adjusted by either winding or unwinding the cord on the pulley.

When the crosshead, with cord connected, is at the extreme point of backward travel, there should be sufficient tension of the spring to take up the slack cord. If the cord does not run evenly on the pulley, the position of the indicator should be altered until a perfect and uniform winding of the cord is obtained.

After the card is placed on the paper drum and the outfit is ready to take a diagram, the paper drum should be advanced away from its stop at least one-quarter of an inch, which is accomplished by turning the knurled thumb-piece on its top. While holding the drum in this position, the swivel collar is gently pushed in, which engages the clutch and starts the paper drum in motion. The drum is stopped, as heretofore stated, by arresting its return motion by turning the top thumb-piece.

THE THOMPSON STEAM ENGINE INDICATOR

The original Thompson indicator was patented in 1875, but has been considerably improved upon from time to time.

The radical improvements, as made in the old style Thompson indicator, consist of lightening

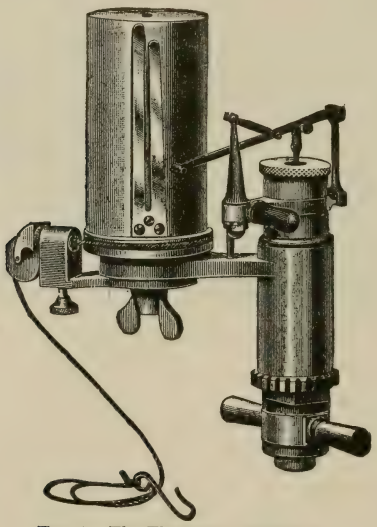


FIG. 1. The Thompson Indicator.

the moving parts, substituting steel screws in place of taper pins, using a very light steel link instead of a large brass one, reducing the weight of the pencil lever, also weight of squares on trunk

of piston and lock-nut on end of spindle, and increasing the bearing on connection of parallel motion. By shortening the length and reducing the actual weight of the paper cylinder just one-half, and by shortening the bearing on spindle, also lowering the spring casing to a nearer plane to that in which the cord runs, the momentum of the

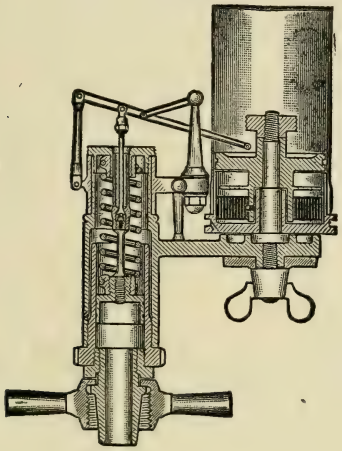


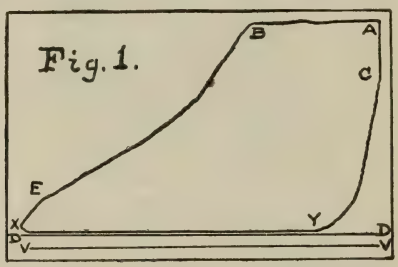
FIG. 2.
The Thompson Indicator.
(Sectional View.)

paper cylinder has been reduced to a very small amount. All of these improvements have lessened the amount of friction, which was heretofore very small, but is now reduced to a minimum; and furthermore, they tend to improve, on the whole, an instrument whose principle has always been of undoubted correctness.

READING INDICATOR DIAGRAMS.

While the diagram is solely a graphic representation of the pressure in the cylinder, and only one side of the cylinder, still by a knowledge of the various operations of the locomotive slide valve much valuable information is gained.

In the diagram, Fig. 1, the line *D D* is the atmospheric line, and is made by setting the indicator drum in motion when there is no connection open between the locomotive cylinder and the indicator piston. The pressures indicated by lines above and below this line from which measurements are taken are those above



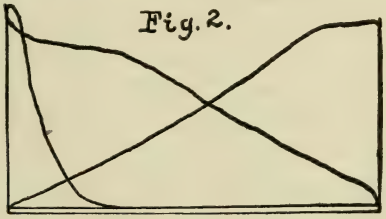
or below atmospheric pressure. The line *V V* is the zero line fourteen and seven-tenths pounds below line *D D*, and drawn by hand after the card is taken. *A C* is the "admission line." Steam is first admitted to the cylinder at *C*, hence that is called the "point of admission." *A B* is the "steam line." *B* is the "point of cut off," after which the pressure in the cylinder drops in expanding; hence, *B E* is the "expansion line." At point *E* the exhaust port begins to open and is thus called the "point of initial exhaust," or "point of release." The exhaust continues to the end of the stroke at *X*. *X Y* is the line of "back pressure." The

exhaust port closes at *Y* and compression begins, *Y C* being the compression line.

The slightest irregularities in the steam distribution of a valve may thus be readily detected by taking an indicator card at a not too great speed.

It is customary to take an indicator diagram from each end of the cylinder, upon the same card. The taking of the second card follows the first as quickly as the three-way cock can be moved. Having the two indications on one card enables the variations between the steam distribution in the two ends of the cylinder to be readily detected.

Fig. 2.



The diagram, Fig. 2, shows unequal steam distribution in the two ends of the cylinder. Looking at card *H* we can see that the exhaust port closes too early and compression exceeds the steam chest pressure (as shown by the loop), which causes the valve to raise off its seat. This card of itself would indicate too great inside lap, but by noting card *O* it is seen that there is no compression at the other end of the cylinder. Hence before any change is made the blades should be adjusted to equalize the two cards. It is always advisable to equalize the distribution in both ends of the cylinder before altering the eccentrics or the valve itself.

THE BOYER SPEED RECORDER.

The principal parts of this machine consist of a rotary pump, a cylinder and a piston. Oil is used as a circulating medium, the pump chambers and cylinder being entirely filled. While the machine is at rest the piston to which the gauge wire and pencil are attached is retained in its lowest position by two coil springs, but when given motion the pump produces a pressure of oil beneath the piston, causing it to rise to a point where an equilibrium is established between the pressure of oil and the tension of the springs, this point being determined by the speed at which the pump is moved—each thirty-second of an inch rise of the piston indicating a speed of one mile per hour. Moving around a drum in the upper part of the machine, at the rate of one-half inch to the mile, is a ribbon of paper, having thereon horizontal and perpendicular lines, each horizontal line from the base or zero line representing five miles per hour, and each perpendicular line a mile post along the road.

If the locomotive is moving at the rate of twenty miles per hour the pencil will trace its mark on the fourth line from the base or zero; and for every mile traveled the paper will move under the pencil one-half inch, or the exact distance from one perpendicular line to another.

By examining the chart, the exact speed at which the train passed any point on the road, the number and location of stops, the distance, speed and location of any backward movement that may have been made, can be determined at a glance.

In the cab of the locomotive, in view of the engineer,

is placed a gauge similar in appearance to a steam gauge, the needle of which points to the number of miles per hour the locomotive is moving. This is connected to the piston of the machine by a small wire

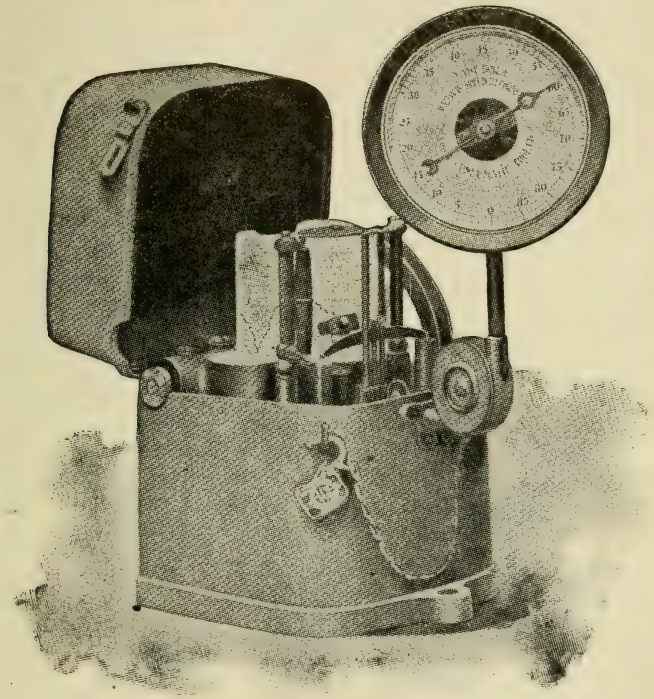
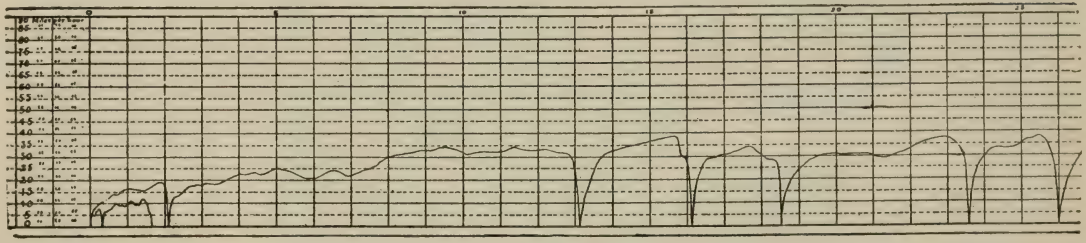


FIG. 1.
Boyer Railway Speed Recorder.

enclosed in a one-eighth inch gas pipe. This pipe runs straight, except where necessary to make a distinct bend, when an elbow of suitable angle, containing a sheave for the wire to run over, is inserted.

FIG. 2.

THIS CUT IS ABOUT ONE-THIRD ACTUAL SIZE, AND WAS TAKEN FROM A RECORD MADE ON A RAILWAY RUNNING WEST FROM ST. LOUIS.



The chart shown in the accompanying cut was placed in recorder while the engine was at the round-house, in such a position as to bring the mile-post, marked zero, under the pencil at the Union Depot, which is about 1⅘ miles from the round-house. It will be noticed that the engine made one stop on its way backing down to the Depot.

After pulling out with the train the first stop was made at a point a little more than 2 miles from the Depot: the second stop was made at Kirkwood, somewhat more than 13 miles distant from the Depot. The highest speed attained between the first and second stops was 35 miles per hour.

The recorder can be placed in a special car or caboose when desired.

The size of recorder is nine inches long, seven and one-half inches wide and nine and one-fourth inches high. All the parts are made with the greatest accuracy, and are interchangeable.

Every machine is set up at the factory and accurately adjusted up to ninety miles per hour.

The charts are wound on wooden spools, and are made in various lengths up to one thousand miles.

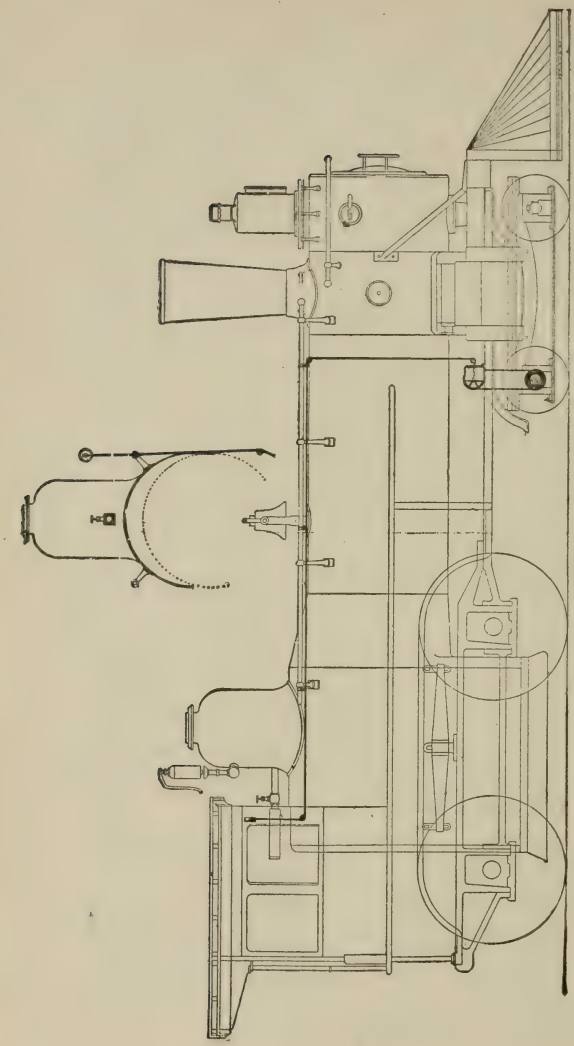
If the recorder is properly applied, the chart will show the actual mileage made, as well as the speed at all points on the run.

Application of recorder.—In applying a Boyer speed recorder to a locomotive with a four-wheel truck, it should be bolted on the frame over the rear-truck axle, with wheel inward. It is usually necessary to bolt a plate of iron on the frame and to set the recorder on that in order to get it far enough in for the belt to pass the truck-box. The pulley to drive the machine should be clamped on the axle, in line with the machine pulley.

This pulley is in two pieces, with a liner between at one side, and should be bored to fit loosely on the turned part of the axle, and when clamped around the axle, the liner should be left out.

When necessary to move the pulley along the axle there need be only one bolt loosened.

In applying recorder to an engine with a pony truck, a disc of suitable diameter, with groove in edge for the belt, should be fastened to the end of the axle, with a cap-screw in center. The recorder, in this case, may be placed on the wheel-guard.



THE BOYER RAILWAY SPEED RECORDER
AS APPLIED TO A LOCOMOTIVE
HAVING A FOUR WHEEL TRUCK

After the machine has been secured in position, place the gauge in the cab where it may be easily seen by the engineer. (It may be fastened on the same bracket that holds the steam-gauge.)

Before the gauge can be fastened it is necessary to remove the dial, in order to put the screws for fastening through the countersunk holes in back.

(The dial can be removed from the gauge by loosening the screws and turning it around until the notch will pass one of the screw heads.)

After fastening the gauge, run a one-eighth-inch gas pipe from it to the recorder. Get it straight as possible, using the elbows containing sheaves wherever necessary. The pipe may be carried along directly under the hand rail and firmly secured thereto by clamps or fastened on the running-board.

Before the pipe is screwed together there should be a thread or small cord passed through each piece, the ends tied together and drawn in. After the pipe, recorder and gauge are in position, the needle of the gauge should be connected with the machine by means of the fine phosphor-bronze wire accompanying the recorder. Take a piece of this wire, long enough to make the connection, with about fifteen inches of silk cord attached to one end and stretch the wire about four per cent.; attach the silk cord to the thread, which is in the pipe at the gauge, and draw the wire through, being careful not to get it kinked.

Place the loop in end of cord on the cross-head hook after passing under the small sheave in the front of machine; then pass the wire around sheave in the gauge out through the notch at the side and around the small screw; then turn the sheave to the left about

half an inch so as to bring tension on the wire, and fasten the end by tightening down the screw, around which the wire is drawn. This done, take the silk cord from the hook on the recorder, move it up and down, and if it moves perfectly free return it to the hook, then put the hand on the gauge with the point at zero.

It will be well to note the manner in which the temporary piece of wire is attached to gauge, which is left there for the purpose of showing the mode of fastening and should be removed before attaching the permanent wire.

It is very important to have the inside of the pipe free from loose scale and dirt, as it may lodge in the ells and prevent the free movement of the sheaves.

In replacing the dial, zero can be placed at lowest point and the head put on to suit.

If, after the recorder has been run for a time, and the hand does not come to zero when the machine is at rest, the hand should be taken off and placed right without disturbing the wire.

When not convenient to put the machine on frame of engine, it may be placed in front of the cylinder and power taken from a thin pulley screwed on the end of the front axle outside of wheel—the same as on engine with pony truck.

The recorder when put in a car is usually placed on the floor, the gauge at a convenient height to be seen, and the belt run down through the floor to the pulley on the axle. In this case the belt and recorder pulley should be boxed on the inside of the car to prevent dust from coming up.

It is usually found necessary to place the machine

within eighteen inches of the center of the car, so as to get the belt around the axle inside of the truck timbers. The recorder may be placed just behind the door, almost against the end of the car, allowing enough space to open the case.

If it is more convenient to have the pulley on the opposite side of machine, as in case of its application to engine with pony truck, it can be so placed by removing the spool plate and loosening the set screw that holds the clutch in center of shaft, then remove the shaft and end bearings and reverse them. The worms and clutch collar should be left in position.

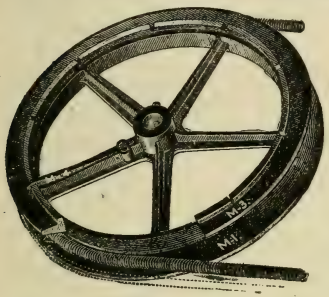


FIG. 3.
Recorder Pulley—Boyer Speed Recorder.

Recorder pulley.—The flange *M*-3 is screwed onto the main part *M*-1, and is held in position by latch *M*-4. The diameter is adjusted, or the point at which the belt runs is varied, by moving the flange to or from the main part. This adjustment is enough to allow for a change of about three inches in the diameter of a car wheel.

The belt should be coupled by means of the plyers furnished, similar to the manner in which the coupling is fastened in one end of the belt sent with the recorder.

Cut the belt of such a length that it will require stretching about eight per cent. to put it in place.

Speeding.—The pulley on recorder should make six hundred revolutions per mile. The diameter of this

pulley is determined by dividing 63,360 (the number of inches in a mile) by the circumference of the car wheel in inches, which gives the number of revolutions of the car wheel per mile; this result, multiplied by the circumference of the axle pulley in inches and the product divided by 600, will give the circumference of the adjustable pulley on the recorder.

Example.—Suppose the wheel be 94 inches in circumference and the axle pulley 17½ inches in circumference, then 63,360 in. ÷ 94 in. × 17½ in. ÷ 600 = 19.66 inches, the circumference of recorder pulley.

To set this pulley to the proper size, take a piece of wire belt the exact length the circumference should be, and adjust the flange of the pulley by raising the latch and turning it until the ends of the piece of belt when passed around will just meet. Be careful not to stretch the belt in measuring. The axle pulley should be measured the same way. (It would be well to measure the axle pulley before putting on axle.)

To ascertain the circumference of the car wheel, a steel tape, or, in the absence of this, a piece of gauge wire may be used, the size being taken at the bearing point of the wheel.

If the measuring of these wheels is carefully done, the record will show a mileage of within one per cent. of the actual distance traveled, and this discrepancy can be rectified by a final adjustment of the recorder pulley.

Care of recorder.—To fill the machine, lift it out of the case and remove the lower spool-plate, which is

fastened by a screw in the center between the spool spindles. The filler-hole will be found directly back of the drum, plugged by a large-headed screw; remove this and fill from the can of circulating oil accompanying the machine. The spout of oil-can should be screwed on loosely, so as to admit air to the can while pouring therefrom. See that the spout is clean, and no dirt gets in the machine.

When the machine is filled to overflow the oil will appear in the bottom of the worm-wheel chambers, and this excess will run out through holes at either side.

It is important to have the machine entirely filled, and to insure this the wheel should be turned while the oil is being poured. After the oil appears in the bottom of the worm-wheel chambers, the wheel should be turned vigorously for a moment to churn out the air which may be in the machine, after which it will take more oil.

A small quantity of oil should be added every six months to replace any that may have evaporated; because, after a length of time, should the oil get below a certain line in the pump chamber, the machine will record low.

In replacing the machine in the case, be careful and keep it as near level as possible, so as not to spill the oil.

Worm-wheels, shafts and bearings should be cleaned about every six months.

The interior of the recorder should not be disturbed, as it is important that the joints remain sealed.

Description and care of oiler.—The inner part of the paper drum is arranged to contain lubricating

oil, and also to gradually feed it to the working parts as the machine moves. The construction is this:

A small tube *J*-3 passes through the bottom of the drum and extends half way up on the inside, to which point the drum is filled with oil. The space above the oil line contains a plunger *J*-4, which is gradually lowered by the slow movement of a screw *J*-5, the latter being operated through a ratchet *J*-7, from an

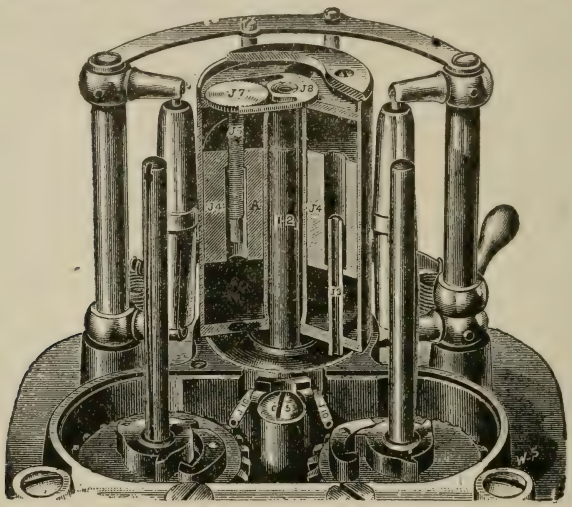


FIG. 4. Oiler—Boyer Speed Recorder.

eccentric on the upper end of the stationary shaft *I*-2, around which the drum revolves. The plunger does not force the oil, it simply displaces and keeps it high enough to run into the top end of and out through the tube. When the plunger stops moving the flow of oil ceases.

To fill the oiler.—Remove the cover by taking out the four screws in the top, then take off the yoke

J-8 that operates the ratchet wheel *J*-7. Turn the ratchet wheel to the right until the plunger within is drawn to the top, when the wheel will stop turning; next, pour the full contents of the bottle of lubricating oil furnished into the large hole. The spout of the circulating oil-can will serve as a funnel.

When the oiler is filled raise it out of its position so that the small tube *J*-3, out of which the oil flows, can be seen; then slowly turn the ratchet wheel in the direction that it will be driven (to the left) until the oil starts to flow from the lower end of the tube; then return the oiler to position, put on the yoke, right side up, and screw the cover on.

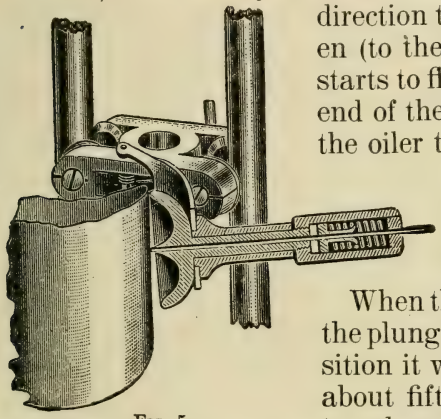


FIG. 5.
Pencil Mechanism Boyer Speed Recorder.

When the oiler is filled and the plunger in its highest position it will require a run of about fifty thousand miles to exhaust the supply of oil. At this time the plunger will have run off the lower end of the screw and will be in its lowest position. In order to again raise the plunger it will be necessary to remove the oiler from the machine and invert it, so as to start the screw into the plunger, to raise it, preparatory to refilling.

It would probably be best to refill the oiler every six months, thereby insuring the mechanism against failure from want of lubrication.

The pencil.—The pencil is brass wire and when in

good condition makes a distinct line on the prepared surface of the paper. It is held by friction and forced against the paper by a spring within the holder.

The pencil should project far enough through the disc on the end of the holder to bear with sufficient pressure on the paper to make a line. Should it project too far through, it will withhold the disc from contact with the paper and will not revolve, which is necessary in order to get a clear line.

To be sure that the pencil is properly adjusted, withdraw the operating lever enough to remove the gripping rolls from contact with the paper, but not enough to remove the pencil, then turn one of the paper spools so as to draw the paper under the pencil; if it is correctly adjusted the pencil will revolve and make a clear line.

Should the pencil not mark distinctly it can be improved by slightly rounding the end on a smooth file, emery or sand paper. The pencil is soft and easily bent, but can readily be straightened by rolling between two flat surfaces of wood or iron. It should be straight as possible in order to enable the spring to hold it against the paper.

To put on the paper.—Loosen the end of the paper and start it on the empty spool by putting the end into the saw cut in the direction that it will not easily come out; wind two or three turns of the paper around the spool, then swing out the operating lever as far as it will go, which will remove the gripping rolls and pencil from the paper drum and place the paper around the drum, putting the two spools of paper on the spindles, with the supply on the left-hand spindle, when facing the direction the loco-

motive or car is to move, then return the operating lever to its former position.

Axle pulley required for application of recorder

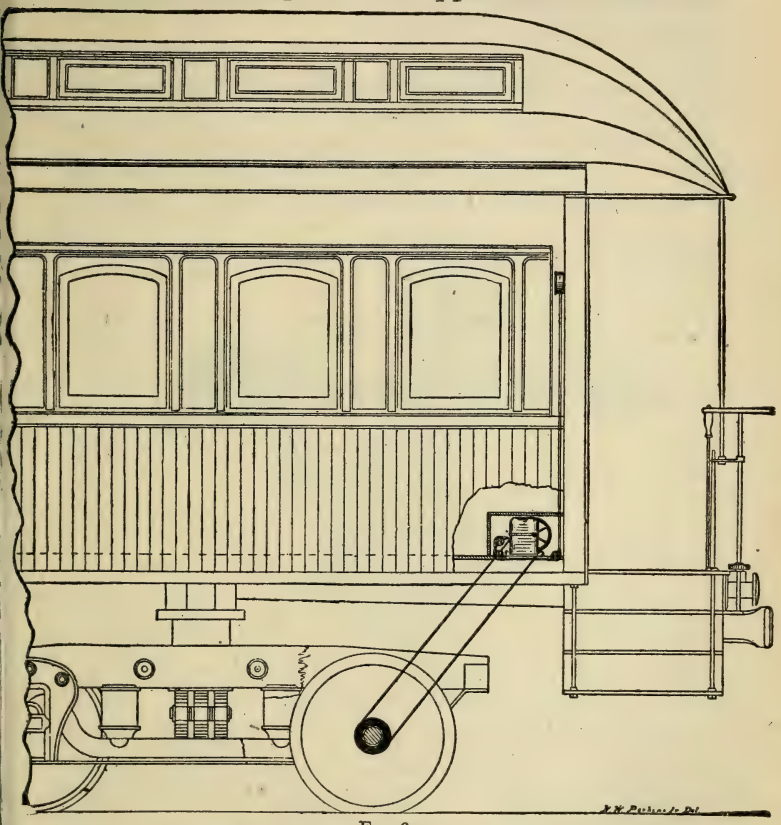


FIG. 6.
Boyer Speed Recorder as Applied to a Passenger Car.

on a car should be split and secured and adjusted to position on the axle by means of six set screws dividing the circumference into thirds, disposed in pairs.

The bore or inner surface of pulley need not be turned out, but should be large enough to clear the rough surface of axle at all points. The length of bore should be about four inches.

LOCOMOTIVE REVOLUTION COUNTER.

The accompanying cut illustrates the Crosby locomotive counter. It is designed particularly for use on locomotives and high-speed engines, and is a valuable

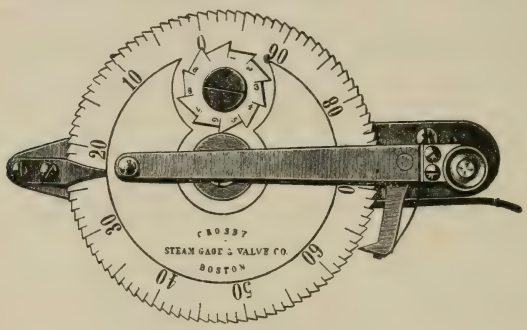


FIG. 1.
Crosby Locomotive Counter.

auxiliary to the steam engine indicator. The arm which moves the ratchet is connected by a cord with some reciprocating part of the engine, or with the drum motion of the indicator, so as to give it about one and one-half inches swing back and forth during each revolution of the shaft. It is provided with a convenient starting and stopping device, so that it can be made to begin or stop counting at any instant.

EMERGENCY KNUCKLE FOR AUTOMATIC COUPLERS

The M. C. B. automatic draw bar has come into general use on American railroads, and its adoption has greatly increased the safety and facility of train handling; but the parts of the draw bar, the knuckle and lock, necessarily give way in

Fig. 1.
Gilman-Brown Emergency Knuckle.

service from wear and tear, and cause trouble by reason of trains parting. When this occurs, if there is a spare knuckle or locking part at hand to replace the defective one, there is little delay in moving the train. But usually the spare part is missing, because it is hardly practicable to carry the assortment necessary to insure having the

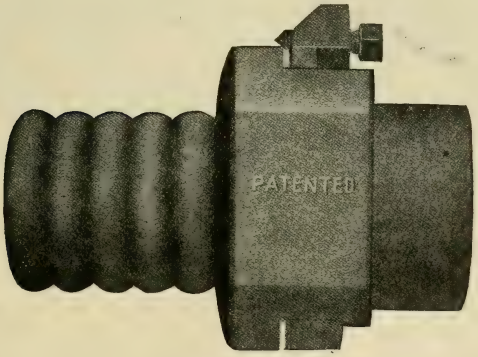
one wanted, there being about ninety different types of draw bars in use. In case the piece is missing, a link and pin or chain is used, and this means a very unsafe and unsatisfactory connection, and probable injury to draft rigging.

The Gilman-Brown emergency knuckle, as shown by Fig. 1, will go into ninety-five per cent of the draw bars in service and make a rigid coupler, into which any automatic coupler will lock securely if in good order. By simply removing or raising the locking pin or locking parts and inserting this emergency knuckle, replacing the knuckle pin, which is seldom injured, a safe and complete connection is assured. The chances are enormously in favor of the emergency being safely and satisfactorily met if there is one of these knuckles close at hand.

It is essentially a repair tool which could well be considered part of the equipment of every freight engine, switch engine and way car, as it is a practical and economical insurance against delay on the road in consequence of defective knuckle or locking parts.

AMERICAN GRAVITY TANK HOSE COUPLING

This coupling can be coupled and uncoupled instantly and cannot be injured, as it guides itself into position when started. It has the same binding force as a threaded union and will tighten with vibration, which is the reverse with the threaded type. The set screw at the top is only for extra precaution to prevent separation in case of derailment. The engine crew will not hesitate to clean the strainer when necessary, as this can be done with ease during ordinary station stops.

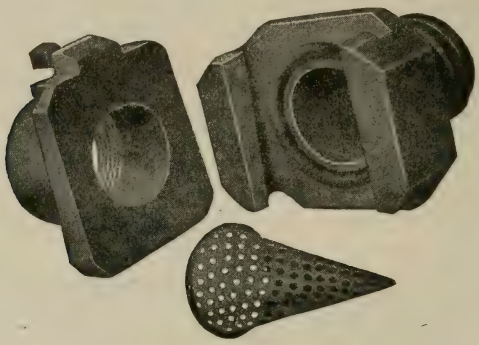


American Gravity Tank Hose Coupling.

This coupling will last indefinitely as there are no threads to be stripped, all binding pressure being against the yielding gasket, which is round and can be turned over, presenting a new face. These gaskets may be made of lead, cast in wooden moulds, at any roundhouse.

Castings are of malleable iron, properly proportioned and accurately machined. All sizes are interchangeable.

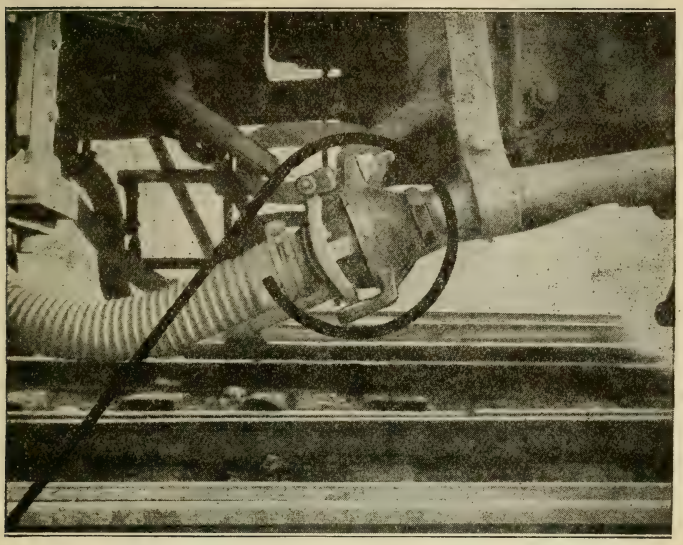
From above illustration it will be seen that the gasket will be compressed by the sliding together of parts A and B. The strainer is placed in the opening in B. The operation of this coupling requires no tools except a small wrench to adjust the set screw in the top. Part A is furnished if desired with wings cast on sides of hub to bolt to a supporting bracket.



Tank Hose Connection.

OKADEE TENDER HOSE COUPLER

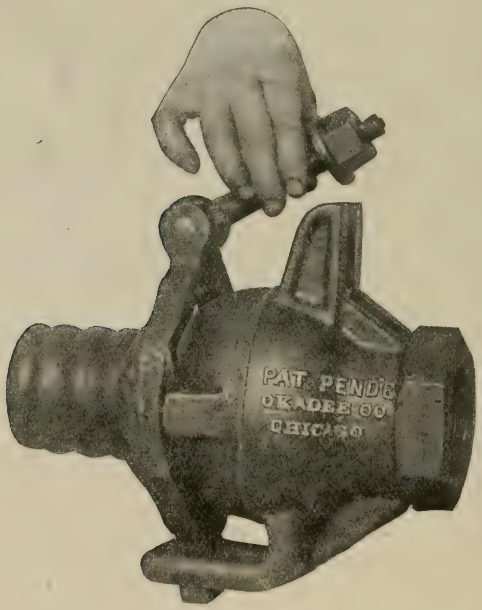
The Okadee tender hose coupler is simple in construction, durable and reliable. It can be disconnected, cleaned and connected in about one minute, without the use of a hammer or large wrench. A few turns of a monkey wrench will release the nut and allow the coupling to be opened. The nut does not have to be taken off of the bolt, and a cotter pin prevents its being lost.



Okadee Tender Hose Coupler.

No coupler can be successful which requires the use of a hammer to loosen it, as is often necessary with union joints, as the use of a hammer on a coupler not only destroys the coupler, but loosens the pipe joints in feed pipes to the injectors, and destroys the vacuum necessary to their successful operation.

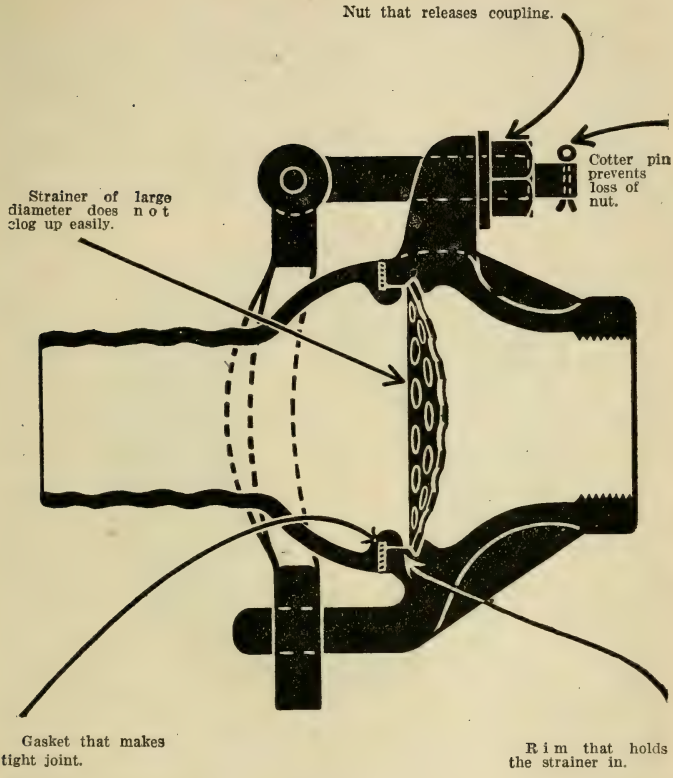
Most injector failures are caused by coal, rust, or other refuse, such as grass, moss, and foreign substances that get into the water tank, being drawn into the injector on account of the lack of a proper strainer in the tender hose coupler. To insure against such accidents, the strainer is pressed into place in the Okadee tender hose coupler in the feed pipe end



Okadee Hose Coupler.

of the coupler, where it will never have to be removed to clean it.

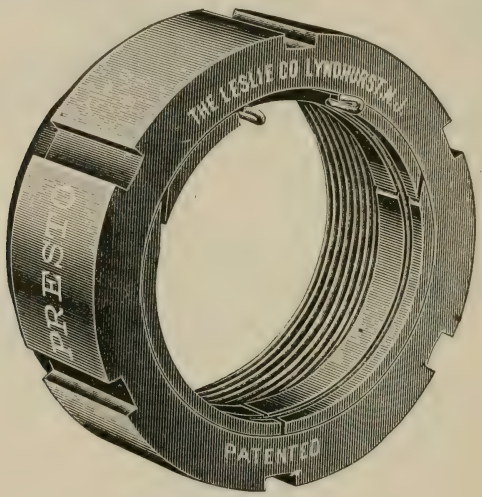
This coupler is also designed for use in engine houses to connect washout and fill up hose to hydrants. It is a time-saver, and besides this, saves the loosening of pipe joints caused by the use of a hammer.


Nut that releases coupling.
Cotter pin prevents loss of nut.
Strainer of large diameter does not clog up easily.
Gasket that makes tight joint.
Rim that holds the strainer in.

The illustration above shows a sectional view of the Okadee tender hose coupler. One of the greatest advantages of this coupler is the strainer, which has twice the diameter of the ordinary cone strainer. This construction is much less likely to be clogged up by foreign matter on account of the greater surface of the strainer.

PRESTO COUPLING NUT

The Presto Nut was produced to eliminate the troubles with injector couplings, and to avoid having to disconnect and take down pipes to make repairs, as has to be done where the ordinary coupling nut is used; it can be put on or changed on the pipe in a moment, and therefore dispenses absolutely with all cost of taking down injector pipes, and in melting the sleeves or nipples off and brazing them on again.

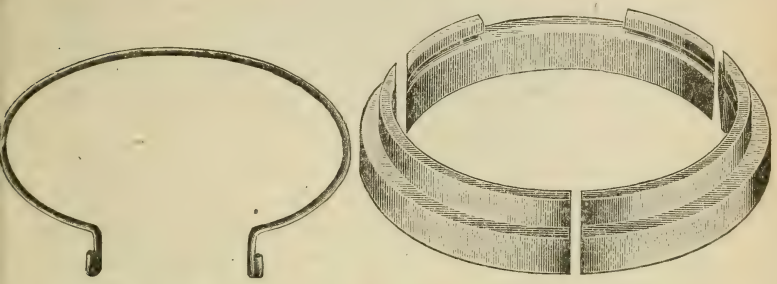


The Presto Coupling Nut.

This cut shows the Presto Nut with spring and sectional ring removed, ready to be slipped over collar of union sleeve, without having to take down the pipe, melt off the sleeve or nipple, and braze it on again, as has to be done with ordinary nuts.

With this nut there is no necessity of an engine having to be laid off its run, on account of failure of injector couplings occurring at a critical time, as with the Presto Nut a new nut can be applied in a moment without the aid of either pipeman or coppersmith, and at any place on the road.

To put the Presto Nut on pipe, first remove spring and sectional ring, put nut on backwards over shoulder and sleeve onto pipe; hold bottom of nut up against bottom of pipe while you insert one of the sections with square end into groove in nut, then slide that section around in groove until it is lying in bottom of nut. Then hold bottom of nut up against bot-



tom of pipe and insert the other section with square end so that the two will come together. Slide the second section around in the groove until the two square ends come together about the center of the bottom of the pipe, then hold the bottom of the nut up against the bottom of the pipe, and insert the section having both ends beveled and hold it up in groove of nut while you slip the spring into the groove in ring, so that ends of spring will project through notch cut in last section of ring inserted, then slip nut up on sleeve and into position for coupling.

To take off a Presto Nut over collar or flange of union sleeve on a pipe, without taking down pipe or having to melt the sleeve off, back the nut off from sleeve on to pipe, then turn nut until section of ring having both ends beveled is in top of pipe, press ends of spring together with finger and thumb, and take spring out. Hold bottom of nut up against bottom of pipe, and then take out the section of ring which has both ends beveled, turn nut on pipe so as to bring one of the other sections on top of pipe, and again hold bottom of nut up against bottom of pipe, and remove the section on top of pipe; then remove the remaining section in a similar manner. The Presto Nut will then slip over the collar or flange of the union sleeve without even having to take the pipe down.

CAST STEEL FOR LOCOMOTIVE PARTS.

The use of cast steel in place of wrought or cast iron is of quite modern practice. The object accomplished thereby is a reduction of cost over wrought iron and a lightening and strengthening of parts formerly constructed of cast iron.

The first locomotive parts to be made of cast steel were the centers of driving wheels. As cast steel is ordinarily considered about three times as strong as cast iron, the section of all parts of the wheel center

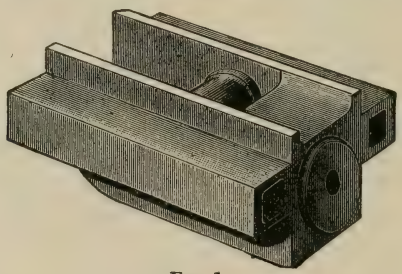


FIG. 1.
Hollow Cast Steel Cross-Head for 4-Bar Guides.

was thus safely reduced, making them more symmetrical, lighter, and still much stronger.

The weight on driving wheels being such a governing factor in determining the size and design of new locomotives, this practice of effecting a reduction of from two thousand to three thousand pounds in the driving wheels of a locomotive, and permitting the same weight to be added to the boiler, is a very important one in American practice.

Subsequently the substitution of cast steel for wrought iron in locomotive cross-heads came into

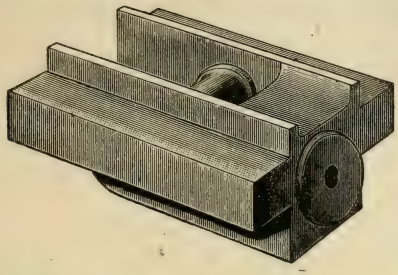


FIG. 2.
Solid Cast Steel Cross-Head for 4-Bar Guides.

quite general practice. Figs. 1 and 2 show hollow and solid cast steel cross-heads for four-bar guides. Fig. 3 is a cast steel cross-head for two-bar guides.

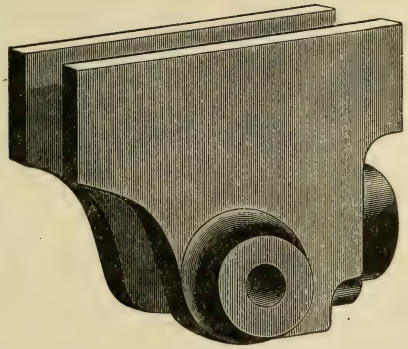


FIG. 3.
Cast Steel Cross-Head for 2-Bar Guides.

These can be made lighter than wrought iron cross-heads, are less liable to flaws in their manufacture, and are much less in first cost.

Fig. 4 shows another substitution of cast steel for wrought iron in the rocker arm. (For the location of the rocker arm see plate "American Steam Locomotive," part numbered 116.)

Until quite recently all locomotive driving boxes were made of cast iron. Although they were of very great weight and thickness, their breakage was of frequent occurrence. Fig. 5 shows a light driving

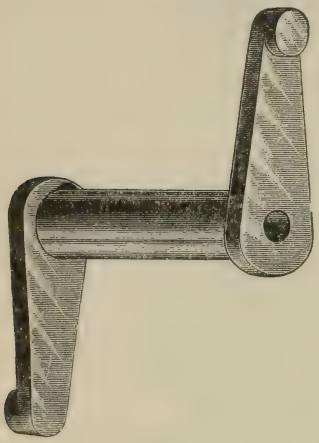


FIG. 4.
Cast Steel Rocker Arm.

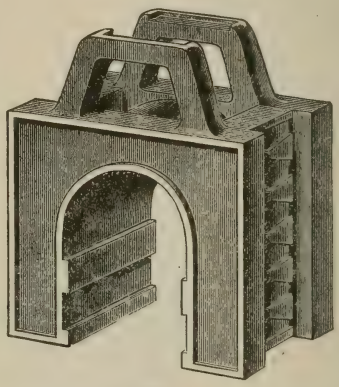


FIG. 5.
Cast Steel Driving Box.

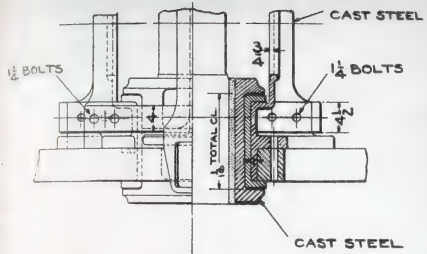
box made of cast steel, thereby reducing considerable unnecessary weight from the driving wheels.

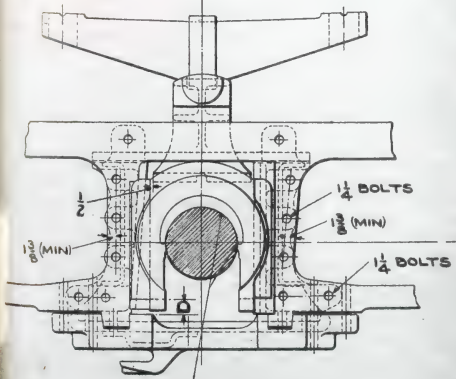
Many locomotive parts formerly made of wrought iron, malleable iron and brass are now cast of steel. Perhaps the most notable of these are the engine frames, which have been found to give excellent satisfaction, and at a saving of from three to four cents a pound effected by the time they are ready to put into the engine.

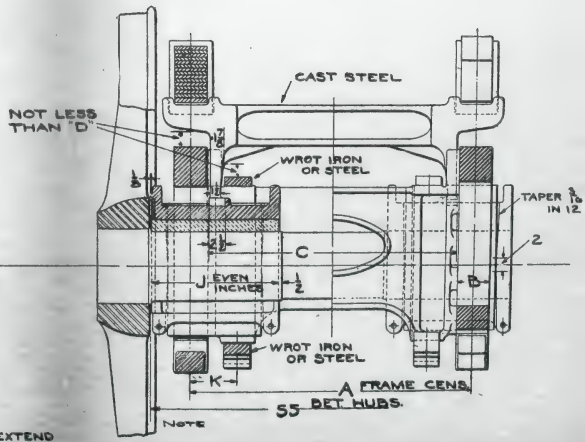
TABLE
SHOWING INCREASE IN BEARING AREA DUE TO EXTENDED BOX.

ORDINARY BOX	EXTENDED BOX	ORDINARY BOX VERTICAL	ORDINARY BOX HORIZONTAL	EXTENDED BOX VERTICAL	EXTENDED BOX HORIZONTAL	GAIN %
9 X 12	9 X 19	108	54	171	85½	58
9½ X 13	9¼ X 20	123½	61⅞	190	95	54
10 X 13	10 X 20	130	65	200	100	54
11 X 14	11 X 21	154	77	231	125½	50

A	B	C	J	K
41	6	34½	21	8
41	5¼	35	21	8
42	5¼	36	20	7½
43	5¼	37	19	7
43	5	37½	19	7







NOTE BRASS BORED NEAT FIT, TO EXTEND FULLY TO CENTER LINE AS SHOWN.

Sheet No. 1

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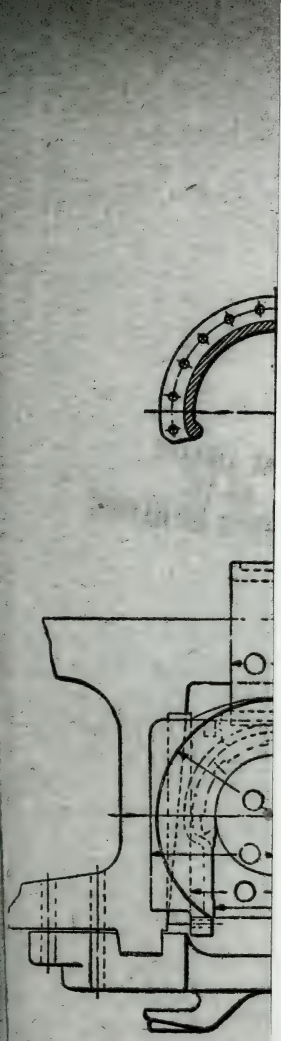
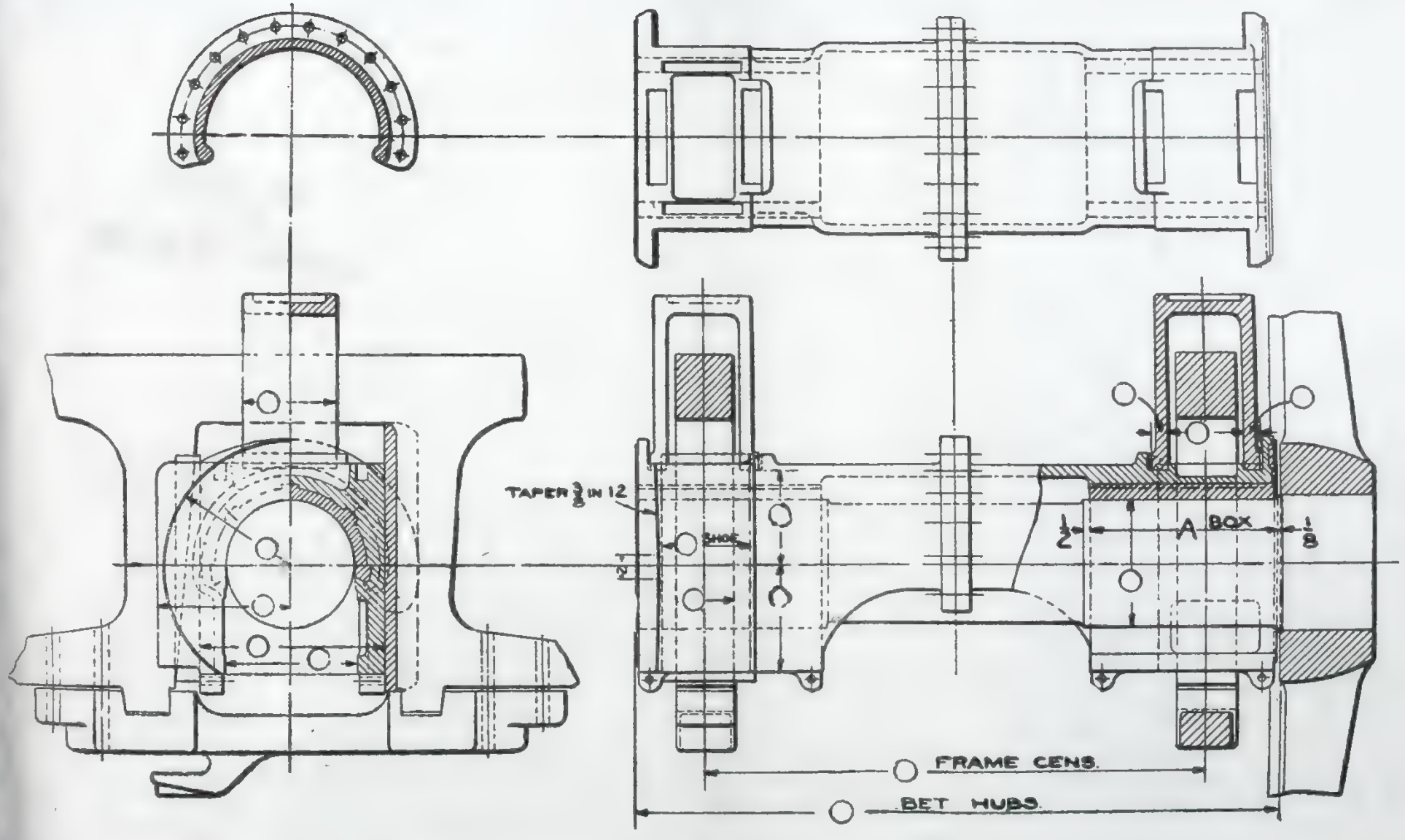


NOTE:
BRASS BORE
BRASSES M
BOXES BOL

PISTON THRUST	A
60,000 TO 73,000	19
73,000 TO 86,000	20
86,000 TO 100,000	21
OVER 100,000	22



NOTE:
BRASS BORED NEAT FIT. BOTH BRASSES MUST BE BORED IN PLACE WITH BOXES BOLTED TOGETHER, AT ONE SETTING.

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COLE EXTENDED MAIN DRIVING BOX

Main boxes are the foundation of the machinery of the locomotive. Loose main boxes, if neglected, lead to failure of rods, frames, axles, looseness in pin bearings, and rapid deterioration in the Valve Gear, and other machinery parts of the locomotive.

Sheet No. 1 shows application to new power, or if desired can be worked up for existing power.

Sheet No. 2 shows method of applying to existing power without any change to engines other than new main axle.

Large locomotives rapidly develop a pound in main bearings for the reason that the bearing metal per square inch of projected area is subjected to a piston thrust that is from 75% to 150% greater than was obtained in smaller locomotives, as is shown by the following table:

Year Built	Size	Pressure per square inch due to piston thrust. On Standard Main Box
1900	18 x24 to 21x30	Average 1650 lbs. per square inch
1913	24½x26 to 29x28	Average 2800 lbs. per square inch

The following advantages are claimed from the use of the Cole Extended Main Box:

Reduced pressure per square inch due to piston thrust on Extended Main Box (Aver. 1150 lbs.).

Greatly increases the resistance to piston thrust which causes pounding and consequential wear and tear on all moving parts.

Doubles the milage between refitting driving boxes, thereby eliminating the necessity of dropping main wheels at engine houses, keeping engine in service until ready for shop.

Keeps crank pin bearings in better shape during this period.

Lessens failures of frames, axles and other parts due to shocks resulting from looseness in main bearings.

Makes a better riding engine, which means less deterioration to entire machine.

Permits of use of removable or slip bearings in other driving boxes, as the long box will remain closely fitted, and this permits of a floating bearing on other journals.

Vertical load equally distributed over area 50% greater than standard box.

LOCOMOTIVE SMOKE ABATEMENT

Although it is calculated by competent authority that only thirteen per cent of the smoke in the city of Chicago, the largest railroad center in the world, is caused by steam locomotives, still the agitation against the emission of smoke and cinders from locomotives has been so pronounced in most cities that it should prove interesting to know of the following thor-

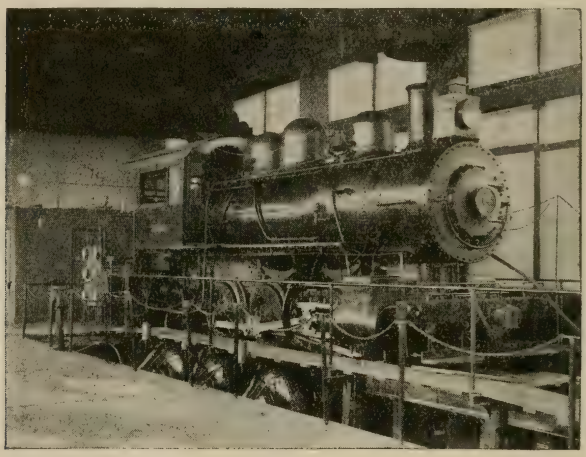


Plate 1.
Engine 7042 in Position on Testing Plant

ough test made at the Altoona Locomotive Testing Plant of the Pennsylvania Railroad Company under the direction of a committee of the General Managers' Association of Chicago.

These smoke-abatement tests were made to determine the merits and proper application of steam jet combustion tubes in a locomotive fire-box for abating smoke, both with and without a brick arch, the special purpose being the development of a specification applicable to locomotives operating in the city of Chicago.

In brief, the results show that if from four to six pounds of air per pound of coal fired is delivered over the fire by steam jet tubes, the emission of smoke will be reduced to a very low amount, and that while the brick arch is a benefit, particularly while the locomotive is running, the steam jet combustion tube is of value either with or without a brick arch.

Description of Locomotive and Test Apparatus:—Locomotive No. 7042 (19-inch by 24-inch) was selected for the tests as being representative of a large class of switching engines in service in Chicago. Plate 1 shows the locomotive in position on the testing plant.

Plate 2 shows a rear view of locomotive on the testing plant.

The locomotive was equipped with a Security brick arch consisting of six rows of bricks supported on two 3-inch tubes with a 5-inch gap between the flue sheet and the front of the arch, as illustrated in Fig. 1.

The steam jet combustion tubes were applied in accordance with Fig. 1. There were eight tubes along each side of the firebox, six above the fire door on the back head, and four below the fire door. The tubes consisted of pieces of 2-inch boiler tubing, approximately 6 inches long, inserted in place of stay bolts, and each tube was provided with a $\frac{3}{16}$-inch steam nozzle connected to $\frac{1}{2}$-inch steam line. Separate valves controlled the steam admission to each set of tubes and the piping was so arranged that the position of the nozzles could be changed as desired. Arrangement was also made to use air in the nozzles in place of steam. A gauge connection to each line was made so that the desired pressure in the line could be maintained.

The blower line consisted of a $1\frac{1}{4}$-inch steam pipe from the steam turret to the smoke-box connection, which latter connected to the exhaust nozzle by a one-inch pipe. The blower was of the double tip nozzle type and is shown in Fig. 2. Steam admission to the blower line was controlled by a quick-opening flat disk valve, which gave any desired pressure up to a maximum of 130 pounds, as indicated on a steam gauge connected to the line just below the valve, Fig. 1. This valve is the type used on the Chicago & North Western Railroad and is shown

in Fig. 3. (This is the Loedige quick acting blower valve fully described elsewhere in "*Locomotive Appliances.*")

The fire-door was equipped with an adjustable damper and deflector. The damper was set with an effective opening of ten square inches, and the deflector at an angle of 30 degrees with the door, throughout the tests.

The smoke box was of the self-cleaning type, with adjustable lift pipe and deflector.

Method of Making the Tests. Running and Standing Tests: —In order to obtain conditions similar to exacting yard serv-

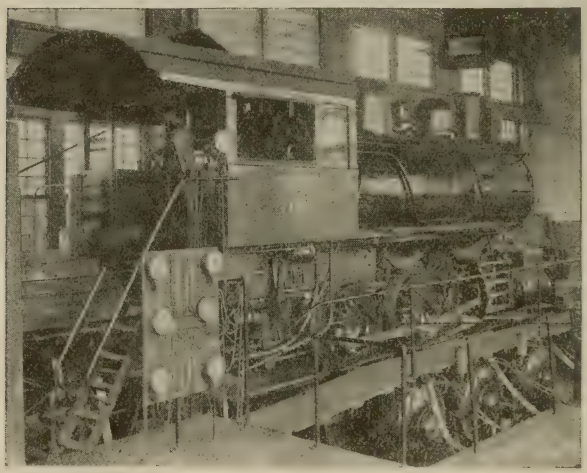


Plate 2.
Rear View of Engine 7042 on Testing Plant

ice, the locomotive was run for seven minutes at a drawbar pull of about 15,000 pounds at twelve miles per hour (eighty r. p. m., reverse lever in twenty-fourth notch, full throttle), and then shut off and allowed to stand for three minutes with the blower on full. The rated tractive effort of this locomotive is 26,517, so that 56 per cent of the rated tractive effort was delivered, which made the locomotive work very hard. The

minimum boiler pressure allowed was 170 pounds, or a variation of ten pounds from the rated pressure of 180 pounds.

To get a good average for each condition, four consecutive running and standing tests were made to constitute a cycle or set of tests.

While running, careful and uniform firing was insisted upon with a light, sloping fire, but as soon as the throttle was closed the fireman promptly threw a stated amount of coal under the front of the arch, to make plenty of smoke. One,

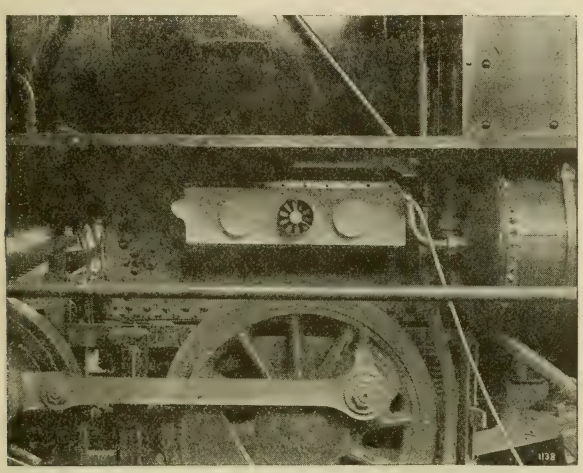


Plate 3.
Wind-Box and Anemometer Measuring Air Injected by Jet Tubes

four, nine and six shovelsful of coal were used for this purpose on the four stops, and is included in the coal used for each test. The standing smoke may be considered as the result of careless firing.

The above cycle of tests were made with each of the various arrangements of steam jet tubes, selected to give data as to the best location of the tubes, the best location of the nozzles in the tubes, and the most desirable amount of air and steam injected by the tubes, with and without the brick arch.

Records of blower pressure, steam-jet pressures and the time the jets were open when running and when standing, coal used, fire-box temperature and drawbar pull were kept, and continuous smoke readings, according to the Ringelmann method, were made from the beginning of each running test until one minute after the stop. It was originally intended that smoke readings would be made at intervals of ten seconds for three minutes after the test stopped. It was found, however, that this time would be too long and would not really represent the average smoke conditions after the stop. The time was

Plate 4
Spark Catcher on Roof of Testing Plant

then changed to one minute after the stop. The results were found in percentages; for example, 20 per cent smoke being No. 1 on the Ringelmann scale.

The amount of air entering the fire box through the ash pan, fire door and steam-jet tubes was determined by the use of anemometers, as shown in Plate 3.

The velocity of the air entering the ash pan was determined, only while running, by the use of an anemometer fitted into a funnel. The funnel was placed in six different positions

around the pan and readings taken for one minute. The average velocity thus determined was used to complete the volume of air entering the ash pan.

The velocity of air through the fire-door openings was determined, only while the locomotive was standing, in a similar manner, except that the funnel was tight-fitting around the damper slide.

The volume of air injected by the steam-jet tubes, both when running and when standing, was determined from a calibration made on one tube with all of the different positions and pressures, using a wind box and anemometer as shown on Plate 3. The wind box was air-tight, being fitted over the steam-jet line, and all air was taken through the anemometer.

The sparks discharged from the stack were caught in a spark catcher erected on the roof of the testing plant, and illustrated in Plate 4. After each set of tests the sparks collected were swept up and weighed. Analyses of eleven representative samples of these sparks were made.

Analyses of the flue gas were made from samples representing the average of the running and standing tests for every cycle.

For tests where the steam jets were closed, but the tubes open, the volume of air drawn through the tubes was taken from the calibration curve.

The brick arch was in place on certain tests and removed for others. On a portion of the tests the gap between the arch and the flue sheet was closed.

On a few tests air was used in the jets, the maximum pressure obtainable being fifteen pounds per square inch.

On other tests the jet tubes were blocked so that the steam only was admitted.

When any one set of jet tubes was in use, all other tubes were plugged with magnesia to prevent air being drawn in.

Coal:—The coal used throughout the tests (except in nine efficiency tests) was furnished by the Superior Coal Company from the Benld Mine in Macoupin County, Illinois, and is representative of the coal used in the Chicago District. Two carloads of this coal were used, the proximate analyses being almost identical. The noticable features of this coal are the

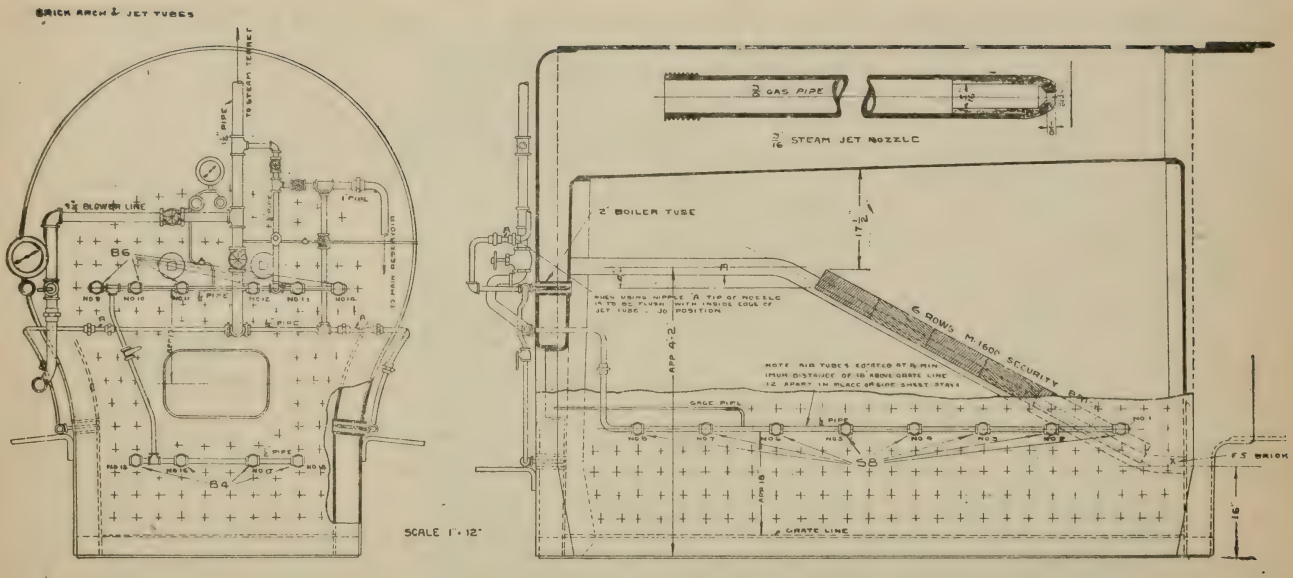


Fig. 1.

Showing Arrangement of Arch, air and Steam Jets, etc., in Fire Box of Locomotive Tested

high ash, sulphur and moisture, which make it a very dirty, clinkering coal, of comparatively low heating value. The calorific values of the two carloads were 11,671 and 12,884 B. t. u. per pound dry coal, respectively.

Efficiency Tests:—After the best arrangement of steam-jet tubes, with and without the arch had been determined, a series of efficiency tests were run at the same speed and cut-off, both with and without the arch to determine the efficiency of the boiler and locomotive with the steam-jet tubes as compared with the same locomotive without the tubes. These tests were run for one hour each.

The coal used on these tests (except two tests) was from the Penn Gas Coal Company, Irwin, Pennsylvania, and had a calorific value per pound of dry coal of 14,520 B. t. u.

It was necessary to use this coal in order to keep up the pressure for an hour under the hard working conditions imposed. Several attempts were made with the Illinois coal, but in each case the locomotive failed to steam, and finally the nozzle was bushed from 5 inches to 4⅜ inches in an effort to make steam. Two tests were made with the bushed nozzle and Illinois coal, but on both tests the steam pressure fell below the limit of 170 pounds before the end of an hour. No difficulty was experienced with Penn Gas coal; however, the smaller nozzle was left in place during the remaining tests.

Firing-Up Tests:—To determine the merits of the steam-jet tube in abating smoke while a fire is being built in a locomotive, or while building up a fire after the fire-box temperature has become very low, a series of firing-up tests were made, using the best arrangement of steam-jet tubes with the arch in place. Starting with a cold boiler, the fire was lighted and built up as rapidly as possible. Continuous smoke readings were made until boiler pressure was obtained. The analyses of flue gases and the varying fire-box temperatures during the various tests were accurately determined.

Conclusions. Smoke.—The steam-jet combustion tube has a decided value in reducing smoke under the widely varied conditions of these tests.

The air injected by the tube was found to be the greatest factor in reducing smoke, although a small amount of steam seems essential in smoke reduction.

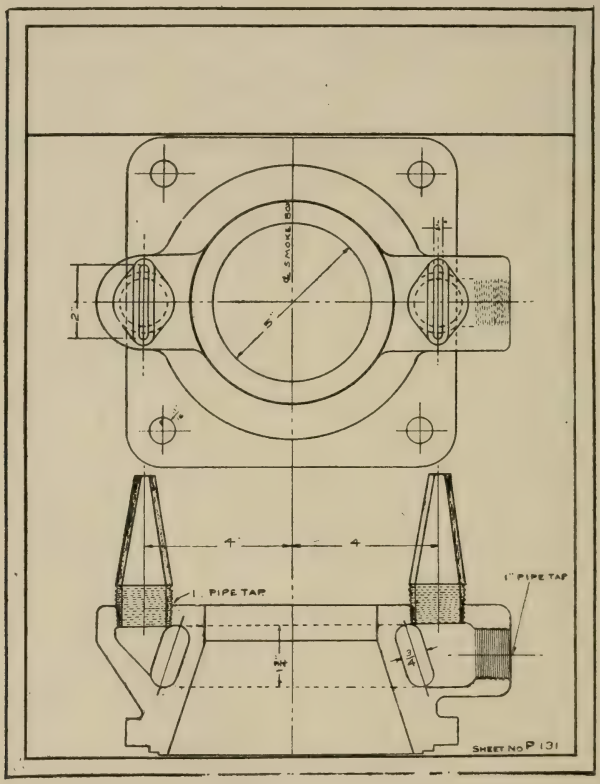


Fig. 2.
Double Tip Blower.

When using steam jets, injecting air into the fire-box, it was apparent that a greater reduction in smoke was accomplished by their use with improper firing as compared with careful firing.

The fire-box temperature was found to be higher when the arch was in service as compared with the plain fire-box, although the data do not consistently show that a reduction in smoke follows increased fire-box temperature.

The brick arch showed a considerable reduction of smoke when running, due presumably to higher fire-box temperatures and better mixing of the gases of combustion, while on the standing tests the brick arch showed little, if any, benefit in the way of smoke reduction when the proper mixture of air and steam is supplied.

The steam-jet tubes seem to give the best results in preventing smoke when located so that the injected air and steam meet the flame as high as possible above the fuel bed. If the arch is used the best results seem to be obtained when the air passes underneath the arch as high as possible above the fuel bed.

The arch gives better results in smoke prevention if it fits tight against the flue sheet. A tight arch, however, has the practical disadvantage of collecting deposits of sparks and eventually closing the lower flues.

An efficient design of smoke-box blower is an important factor in smoke abatement.

Air openings in the fire door are of slight assistance in smoke abatement, as they are capable of supplying only about ten per cent of the air necessary above the fire and a very small percentage of the total air for complete combustion.

Best results were obtained when from 4 to 6 pounds of air per pound of coal fired was injected by the steam tubes in the fire-box.

It was found on these tests that the total amount of air, including that which was introduced above the fire, should be not less than 13 pounds per pound of coal for good smoke prevention.

The data seem to indicate that the best results can be obtained when the least amount of steam is injected with the greatest amount of air.

Economy.—The use of the steam-jet tubes results in considerable economy, and in the efficiency tests an increase in evaporation was obtained.

Sparks.—The steam-jet tubes apparently reduce the weight of sparks discharged from the stack, but the data were not of a character to firmly establish this point.

Blower Valve.—There is a necessity for a quick-acting, easily

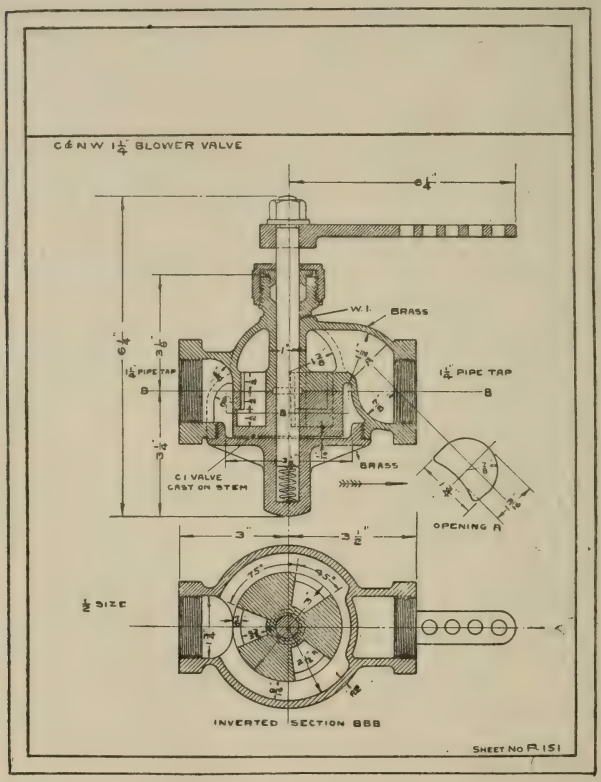


Fig. 3
Quick Acting Blower Valve

operated valve capable of giving reasonable graduations in pressure.

Steam Nozzles.—It was found during the tests that the steam nozzles were being worn by the steam and this accounts

for the inability of the steam lines to supply as great a pressure to the jets as desired in some of the later tests. The nozzles were made of brass. The indications are that they should be made of steel, and, if necessary, hardened.

The $\frac{3}{16}$-inch diameter steam nozzle seems to be the desirable one to use in a 2-inch tube.

There is noise incident to the use of the steam-jet tubes in the back boiler-head, and if the steam-jet tubes are located in the cab, they should be covered with a $\frac{3}{8}$-inch cast iron box provided with cast iron air intake from a point outside the cab, the air intake being provided with a muffler.

RECOMMENDATIONS

The following recommendations were made as a specification for the application of steam-jet tubes to a locomotive operating in the city of Chicago, and they will produce best results if properly applied, operated and maintained, in any locality.

Jet tubes of a minimum outside diameter of 2 inches should be used and located on the back head or the side sheets of the fire-box, dependent upon the most efficient location for the specific dimensions and type of fire-box under consideration.

Capacity of Jet Tubes.—The jet tubes should have a capacity of from 4 to 6 pounds of air per pound of coal fired, but in any case they should have not less than a total capacity of 1,200 cubic feet of air per minute. The measurements of air to be based on the calibration in this report.

Steam Nozzles.—A $\frac{3}{16}$-inch diameter steam nozzle should be used in each tube.

A bracket or standard of some kind should be used so that the nozzle will be in line with the center of the tube.

The tip of the nozzle should preferably be made of hardened steel.

Steam Lines.—The size of the steam pipe supplying the nozzles should not be less than ½-inch for six nozzles, and the inlet to the nozzle line should be located as nearly as possible at the center of the entire length of pipe.

The blower line should not be less than 1¼ inches diameter pipe, and should preferably be provided with a quick-acting,

easily operated valve, capable of giving reasonable graduations in pressure.

The blower may be of either the multiple or double tip

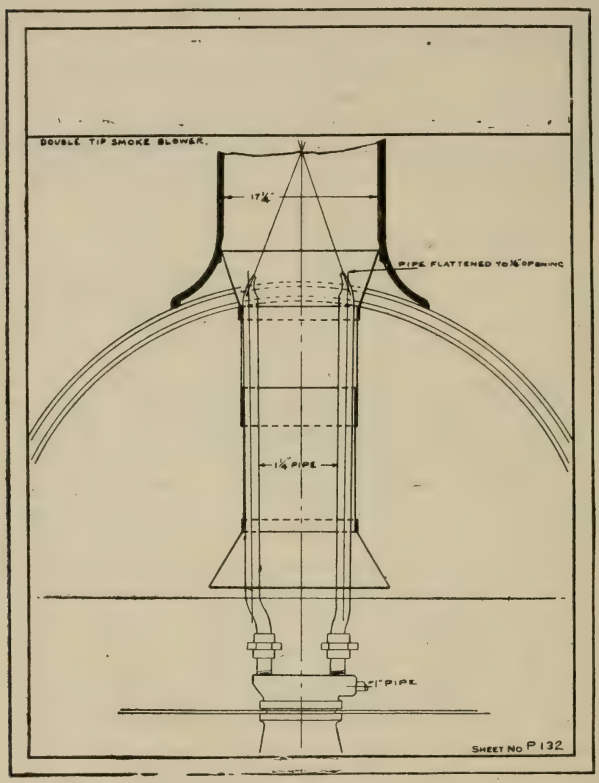


Fig. 4.
Double Tip Blower.

nozzle type, as used in these tests. Preference from a maintenance standpoint is given to the double tip design.

The fire door should have minimum air openings of ten square inches.

The grate arrangement should be such that the air openings through the grate will have an area of not less than 30 per cent of the grate area.

The ash pan should have minimum air openings equivalent to 15 per cent of the grate area.

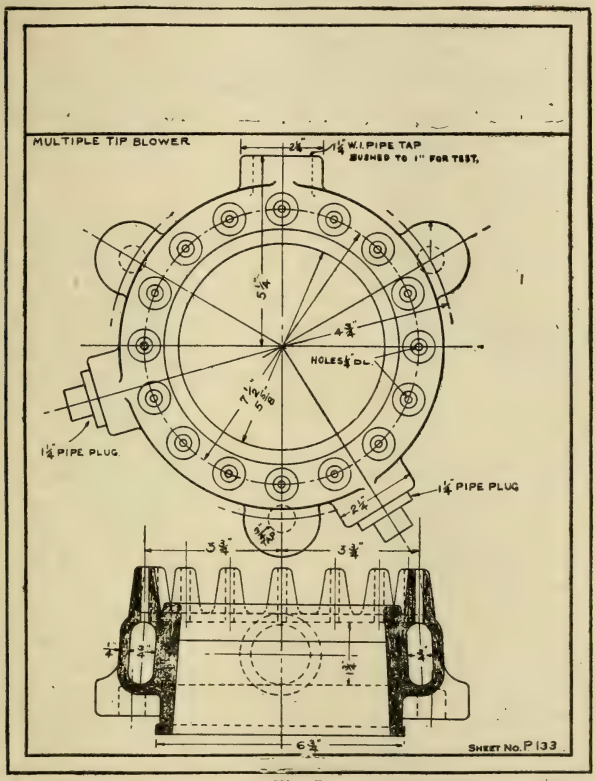


Fig. 5.
Multiple Tip Blower.

Addenda.—During the year following these tests fifteen important railroads have reported that they have applied this recommended equipment to a large number of locomotives with excellent results.

LOCOMOTIVE JACK SCREWS AND POWER HOISTS.

The enormous increase in the weight of locomotives and tenders has naturally been followed by very powerful and efficient jacks, which are required for the purpose of lifting the engine itself or some of its parts.

No one knows as well as the old railway mechanic and his helper the vast amount of time expended every day in raising and lowering even the lighter engines of his day, while with a good set of either geared or hydraulic jacks the heaviest locomotive can be raised a foot in less than a minute and a half, and again lowered with equal or greater celerity.

Before illustrating and describing several forms and designs of jacks now in general use on American railroads, and here mentioned on account of their especial adaptation to locomotive requirements, it would be well to say that no jack, be it ever so powerful, can render efficient service unless it has a firm, unyielding foundation to stand upon. Hence great care should be exercised in the design and construction of a stone or concrete wall on each side of every track in engine houses.

To the uninitiated, let it be said that one or more jacks must be used every time it is necessary to pack a journal, change a spring, spring hanger or equalizer, remove a pair of wheels, or change the driving wheel tires, etc. Thus, there is scarcely a day but what

from some cause some part or the whole of an engine or tender must be raised.

Fig. 1 shows a screw jack with the bottom end enclosed, forming an oil receptacle. The screw being thus lubricated and protected, does not become rusted and is always ready for service. As two or more screw jacks are usually carried on every locomotive

Fig. 1.
Chapman Screw Jack.

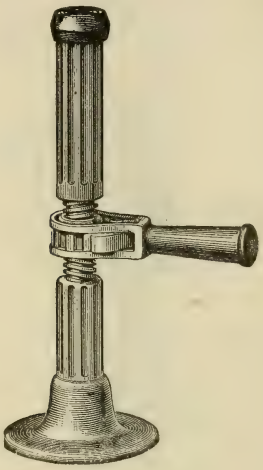


Fig. 2.
Joyce Double Movement Screw Jack.

for instant use in case of break-down on the road, and unless the screw portion is properly protected, they soon rust and become unfit for service.

Fig. 2 shows a double movement screw jack, which lifts twice as rapidly as a single screw, and, it is claimed, requires no more power on account of there being no friction under the cap, as in the case of the latter.

The rapid moving jack shown in Fig. 3 is so called because, when the load is off, it can be raised immediately to any desired point, and when up can be as quickly let down, thus saving the tedious operation of turning the screw up and down without load. The two segmental nuts are supported on steel pins moving in angular slots, so as to allow them to move in and out of gear. To raise the screw to any desired height for work, it is only necessary to lift it by taking

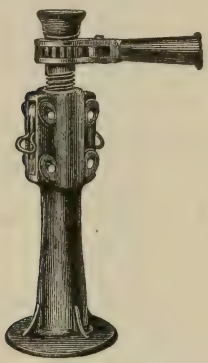


FIG. 3.
Joyce Rapid Moving Screw Jack.

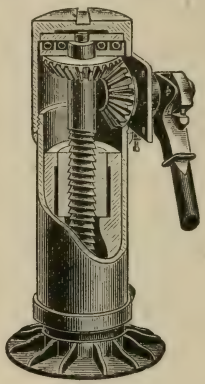


FIG. 4.
Norton Ball-Bearing Ratchet Screw Jack.

hold of the lever. To lower it take hold of one of the handles with the left hand, and inclining the jack to an angle of about forty-five degrees, with the other hand holding the lever, let the screw down.

The jack shown in Fig. 4 has a stationary standard and a sliding sleeve fitting over the same. The standard has a removable nut (usually phosphor-bronze) fitted within it and resting on a shoulder, in which the screw turns. The standards are hollow and

can be filled with oil, thus keeping the screw constantly lubricated. To the upper end of the screw is fastened a steel gear; a hardened tool steel plate encircles the hub, and rests on the body of said gear, on which are placed circular trains of hardened steel balls, held in place by rings between the rows (as shown in the cut). In the top or head of the sliding sleeve, which is bored to fit standards, is placed another hardened tool steel plate with a hole in the center, through which the end of the screw projects.

When the jack is assembled the sleeve slides down over the screw and standard, the bearing plate in the head resting on the balls on the plate on the gear, so that the whole weight is carried by the balls (between the steel plates), which act as a thrust-bearing between the screw and head of sleeve, reducing the friction and increasing the lifting power of the jack.

The sleeve which revolves on the standard, allowing the lever to be used from either side, carries the load, and is raised or lowered by the screw, which is turned by means of a gear on the ratchet shaft engaging with the gear on the screw, and operated by a reversible ratchet and lever having the up-and-down, or "pump-handle," motion. The sleeve at the lower end is provided with a "stop-dog" or pawl, which prevents the screw from being run out of the nut. This sliding sleeve takes all the side strain off the screw, preventing it from bending, and also protecting all the working parts from sand, coal-dirt and water, making it an efficient jack for carrying on locomotives or for use in engine houses.

Fig. 5 gives a general idea of the Joyce geared jack. A wooden handle fits into the socket shown. The

bar has strong, heavy teeth operated by a pinion, which in turn is operated by a wheel mounted on the same shaft with it. The wheel is operated by a lever and pinion. This mechanism gives the advantage of a fine-toothed bar for power without the weakness of fine teeth, as both bar and wheel have strong and durable teeth. The jack raises one-fourth inch per stroke of the lever, and yet the pitch of teeth on the bar is one and nine-sixteenths inches and on the wheel one inch.

To adjust the jack for raising the load, turn the small crank in the frame near the lever straight up; for lowering the load, turn this crank straight down.

For shop or wrecking purposes, especially in confined quarters, where a screw jack or a pumping jack could not be well operated, the hydraulic jack is most rapid, powerful and efficient.

FIG. 5.
Joyce Geared Locomotive Jack.

There are several designs of hydraulic jacks, each differing from the others in no essential feature; hence it will suffice to illustrate but one or two designs.

The principle upon which the hydraulic jack works is that of a pump. The lowering is done by a movement of the handle reversed, or, as in the case of the jack shown in Fig. 6, by a thumb screw, the location of which is indicated. These jacks can be lowered steadily and to any extent, without the slightest jar, even when loaded to their greatest capacity.

In the jack shown the valves are all on the end of the

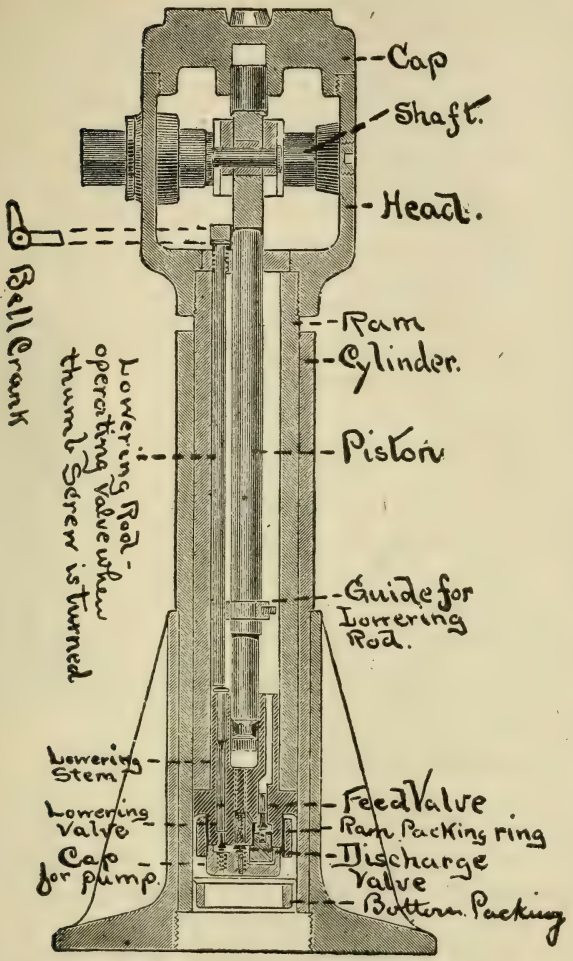


FIG. 6.

Sectional View of Justice Hydraulic Jack.

ram, and are accessible by simply withdrawing the ram from the cylinder, and removing a small cap. This enables a person of ordinary intelligence to examine the valves and remove any obstructions that may interfere with the working of the jack. This is a great advantage, as none of the working parts need be disturbed to examine the valves and repair same when necessary.

These jacks will work horizontally to two-thirds of their run-out limit.

The "rocker shaft" which operates the pump rod passes through a stuffing-box to prevent leakage, and terminates in a square boss. This permits of the lever being applied in any one of four positions, which is frequently of great advantage when working in cramped quarters, clearing away wrecks, etc.

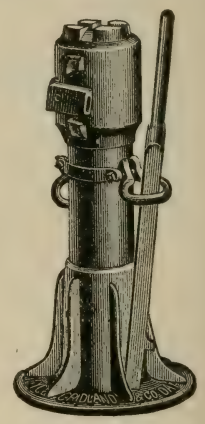


Fig. 7.
Joyce Hydraulic Jack.

Directions.—To fill the jack, remove slotted screw in the head. The best fluid for filling is made one part water, six parts alcohol and one-half part of good oil (sperm preferred), well shaken together before putting in the jack. Never use coal oil, wood alcohol nor water only in filling, as the two former destroy the packing, and the latter may burst the cylinder in freezing weather and rusts the metal.

In using the jack, press the lever with a quick surge, and move the handle upwards suddenly, in order to give the valves a chance to react quickly.

The thumbscrew valve should be screwed outwards a few turns when raising a load. In lowering, screw this valve inwards slowly. This valve, being independent of the pumping mechanism, gives absolute control over the speed or distance of the lowering weight, and a half turn of the thumbscrew will stop the load at any point without the slightest jar.

Should the jack refuse to work on account of the valves sticking to their seats or from air entering the pump, by striking the lever a few sharp blows, up and down, the valves will be jarred loose and the air expelled.

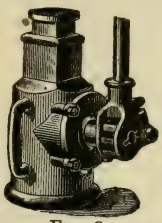


FIG. 8.
Geared Journal Jack.

The levers are all made the proper length for one man (of about one hundred and fifty pounds weight) to lift the full capacity of the jack. In no case must more than one man work the lever, nor must the handle be lengthened, as damage to the jack will be the result.

The jack will work to best advantage if the slotted filling screw in head is slightly loosened when in use; this allows the escape of air in the jack, and prevents the "springy" motion to the lever.

Fig. 8 shows a small-geared jack of fifteen tons capacity, for jacking-up the box of a tender or engine truck.

Compressed air has played so large a part in economical shop practice, and hence it is not surprising

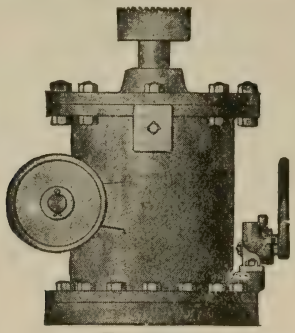


FIG. 9.
Portable Air Jack.

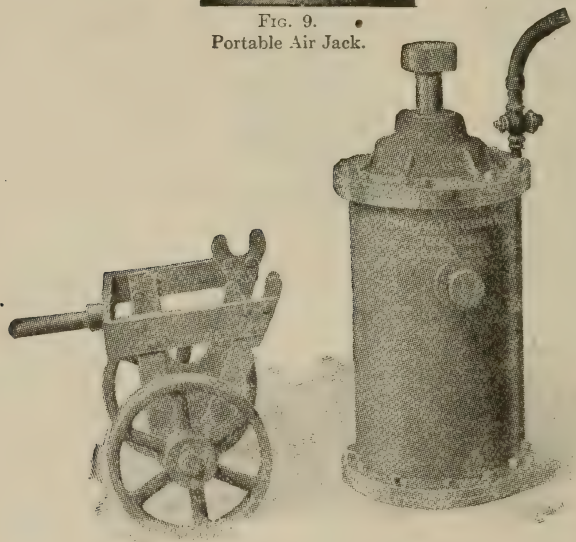


FIG. 10. Air Jack and Carriage.

to see large, portable air jacks, as shown in Figs. 9 and 10, in use for raising locomotives and tenders, where the engine house and shops have compressed air.

Fig. 11 shows a general view of a chain hoist with a pneumatic motor as an actuating medium.

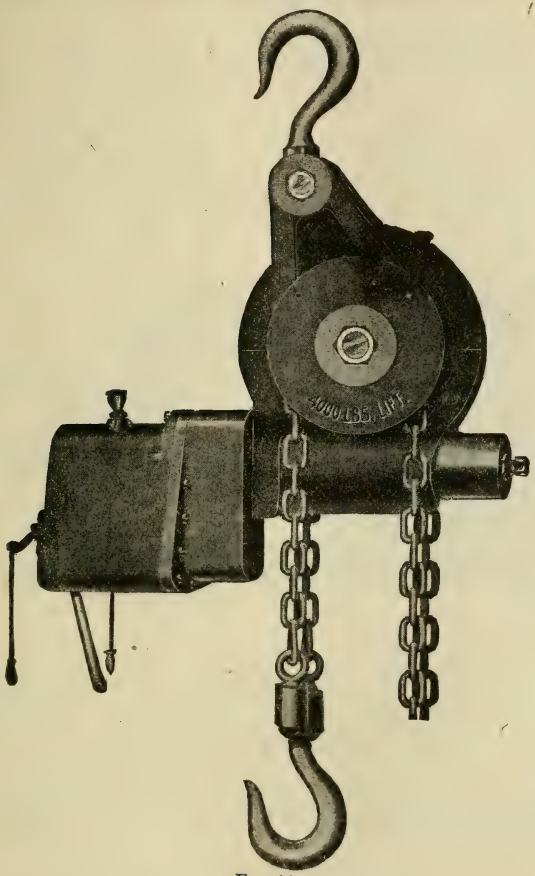


FIG. 11.

"Little Giant" Pneumatic Motor Chain Hoist.

Will replace hand chain tackle at any place without extra fittings and work with low head room. It lifts two tons eight feet per minute. Weight, 80 pounds.

LOCOMOTIVE OR CAR PUSHER.

The pusher shown in Fig. 1 is designed to take the place of the ordinary iron pinch bar, and is much lighter, gives a much more powerful pushing effect, and on account of the steel knife-edge *D* holding to a

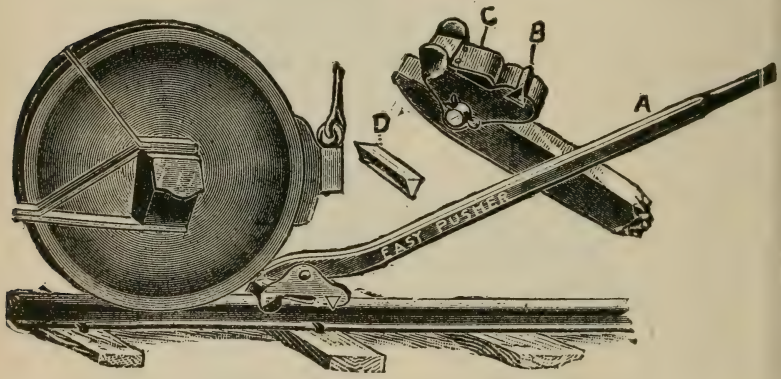


FIG. 1.

slippery rail such a bar is particularly useful about shops and roundhouses, where the rails are usually more or less greasy and slippery.

Many devices of a nature similar to the one here shown are used in pushing cars and locomotives short distances.

LOCOMOTIVE TRACK SANDERS.

Many of the objections that obtained with the hand sanders are overcome with the advent of pneumatic track sanding devices.

There was, perhaps, but one advantage in the old hand sander—that it would deliver more sand in a given time—but this was offset by its many points of disadvantage. Too much sand on the rails makes a train pull hard and, too, most of the sand delivered by gravity at the mouth of the pipe falls or is blown off the rail, and is wasted, and the locomotive, after a very few miles of continuous sanding, is entirely out of sand. To apply the hand sanding device efficiently to both front and rear of driving wheels (as on switching engines) required two sand boxes instead of one, while with many of the pneumatic sanders the single sand box may be used and the sand delivered to any part of the locomotive equally well.

Not a few of the pneumatic track sanders still retain the hand lever and valve as an auxiliary, in case the air pump should fail and there be no compressed air with which to operate the pneumatic device.

Heretofore the matter of sanding has received but scant attention; any gravity system which would deliver sand somewhere on the rail seemed to be equal to all needs.

Gravity sanding devices have no part in to-day's progressive railroading for the following reasons: Such systems are unreliable; they will not deliver

sand promptly and at the point where it will be of the utmost use; they are wasteful of sand, fully fifty per cent. of the sand leaving the rail before the driving wheels reach it, and at times so seriously as to interfere with the working of the present interlocking switch system. The use of more sand than is absolutely necessary tends to excessive tire and rail wear; they are wholly out of the line of progressive railroad improvements.

The gains sought and accomplished by pneumatic sanders are: An economy in the quantity of sand used, amounting to something like a saving of sixty per cent.; the use of just enough sand to bring the best results and no more; the placing of the sand where it is most needed and so that each grain does its share of the work; the instantaneous application of sand when needed; the automatic application of the sand when needed without special effort on the part of the engineer, allowing his attention to other duties when sander is in operation; a great reduction of tire and rail wear and an increased hauling capacity for the locomotive.

In the operation of any locomotive pneumatic sander the air pressure should always be taken from the main reservoir and not from the train line, which might affect the train brakes.

THE LEACH "D" SANDER.

This is one of the most modern and efficient devices used for this purpose. Among the many points of advantage it possesses may be given the following:

It is outside of sand box, accessible at all times for

inspection or when making repairs, and where enginemen and shopmen can, at a glance, understand its operation.

The resistance of the column of sand always above the trap, prevents air pressure from escaping up through the sand box and therefore a high pressure

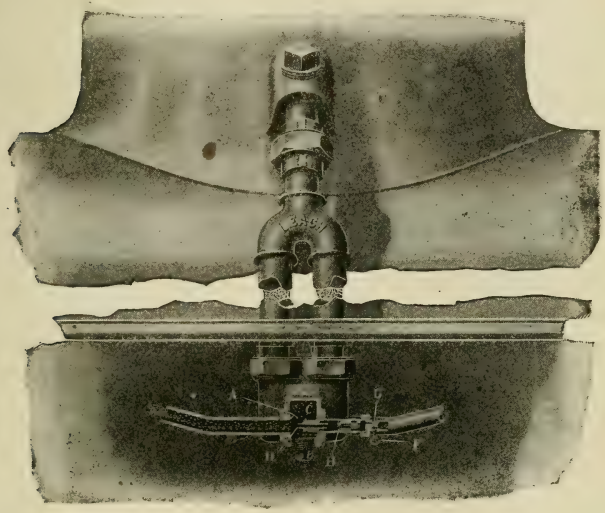


FIG. 1.

Leach "D" Sander, Showing Adjustable Air Nozzle with Check Valve.

is available through discharge pipes for removing obstructions at their lower ends.

The adjustable air nozzle used with this style device can be so adjusted as to regulate the amount of sand discharged to the rail. This nozzle is fitted with a small check valve, preventing air passages from becoming plugged with sand

Fig. 1 shows this type of pneumatic sander as applied to a locomotive, the trap located just under the running board being sectioned. It will be noticed that the discharge pipes are bent up fifteen degrees, to prevent sand from jarring out of the traps when the engine is running. A 1-inch plug at *E* is thus located in order to remove small stones, etc., which may get into traps.

To regulate the amount of sand delivered, increase or decrease the distance *A* by loosening jamb nut *C* and moving the adjusting tube *D* in or out. The greater the clearance *A*, the greater the sand delivery.

Care should be taken to have the nozzles on opposite sides of an engine adjusted alike.

Fig. 2 shows the application to a locomotive with six driving wheels, of the double type of this sander. Care should be taken to rigidly clamp the pipes at the bottom, and they should be so bent as to deliver sand direct to the point of contact between the driving wheels and the rail.

Fig. 4 shows the detail parts of the Leach "D" sanders. This type of pneumatic locomotive sander is used more extensively than any other in this country.

The Leach "A" sander, as shown in Fig. 5, was in very extensive use previous to the introduction of the later "D" style. With this type, the blast is used simply for economy in the use of sand and for convenience in operating. The sand traps are attached to the sand box in the most convenient manner, the sand is supplied thereto through independent outlets from the box, and is discharged therefrom into and through the usual hand lever

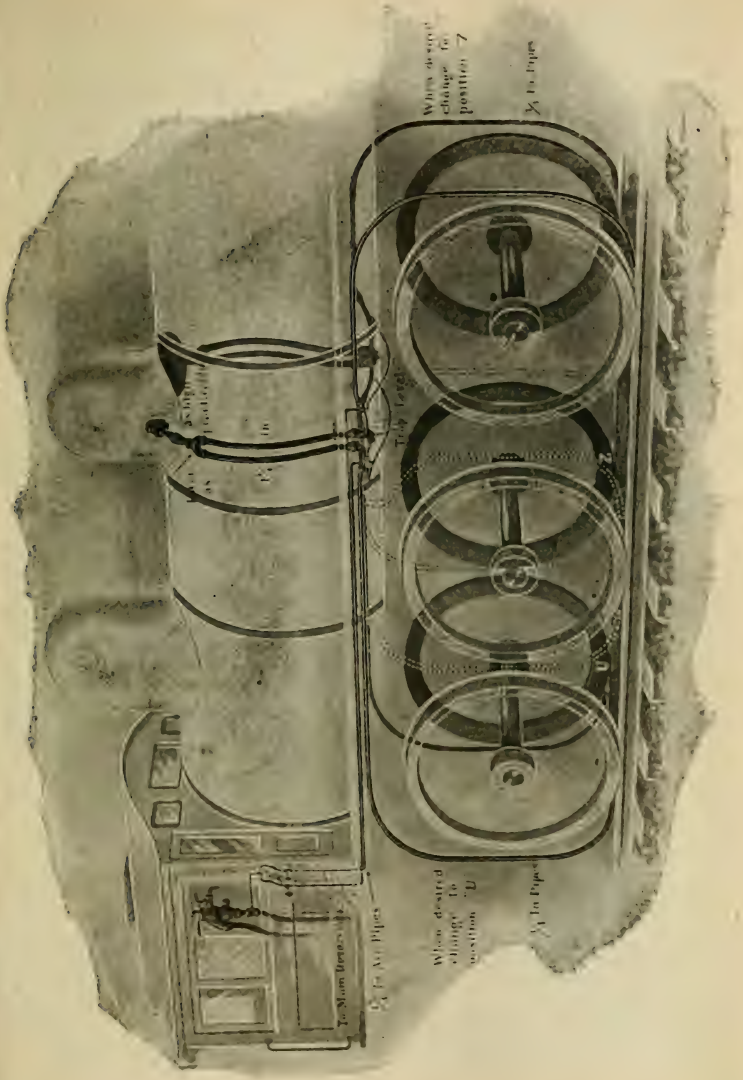


FIG. 2. Leach "D" Double Sander

controlled pipes to the rail, the lever attachment being available for use as desired.

The discharge pipes, usually one and one-fourth

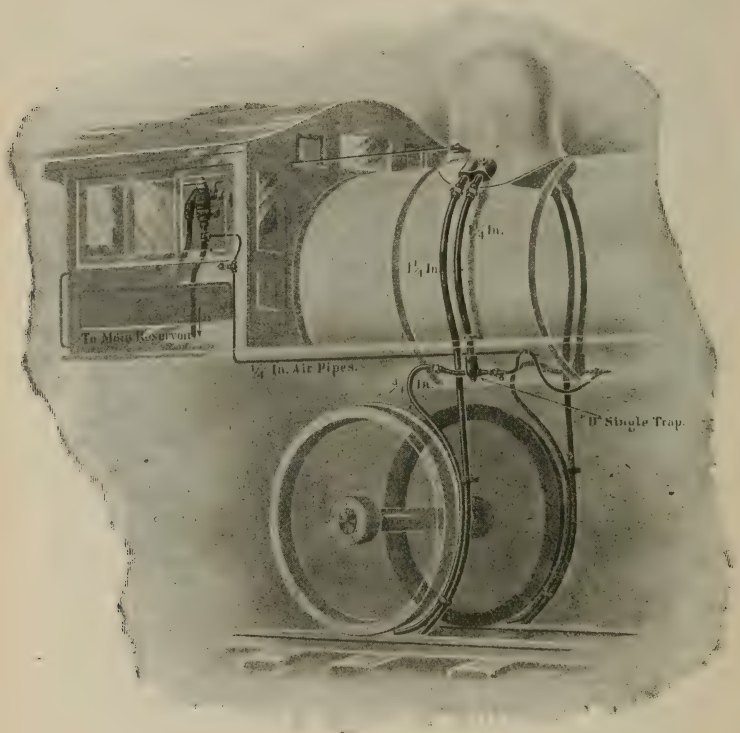


FIG. 3.

Leach "D" Single Sander, Showing Application to an Eight-Wheel Locomotive for Sanding the Rail Going Ahead Only.

inch, must be fitted at such a pitch that sand will flow through them by gravity when the lever is used. The

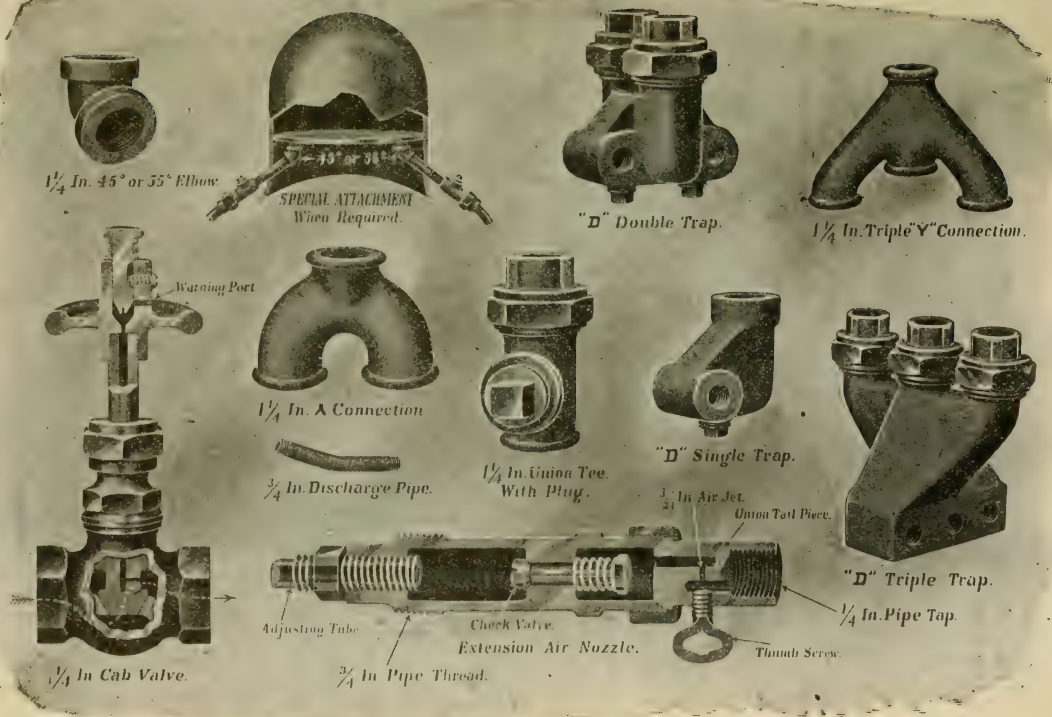


FIG. 4. Detail Parts Leach "D" Sanders.

amount of sand discharged is controlled by the adjustment of cab valve. Hardened caps receive the wear of the sand blast.

Being easily applied and maintained, conveniently

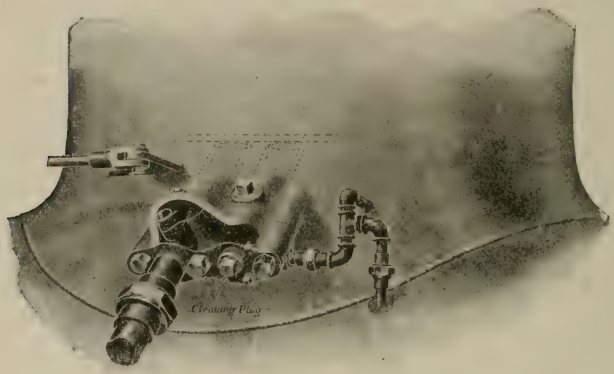


Fig. 5.

Leach "A" Sander.

located for cleaning and very economical in the use of air, they are deservedly popular on many roads where the service conditions do not require the special features peculiar to the "D" type.

THE "SHE" SANDER.

This device is an improvement on the Houston sander (not here shown), and will interchange with the Houston device in every particular.

The action of the "She" sander, as shown in Fig. 6, is that of a syphon and ejector. The syphon used in connection with this device is especially designed to

carry the sand through the pipes to the rail with great velocity, and uses only a small amount of air to accomplish this result.

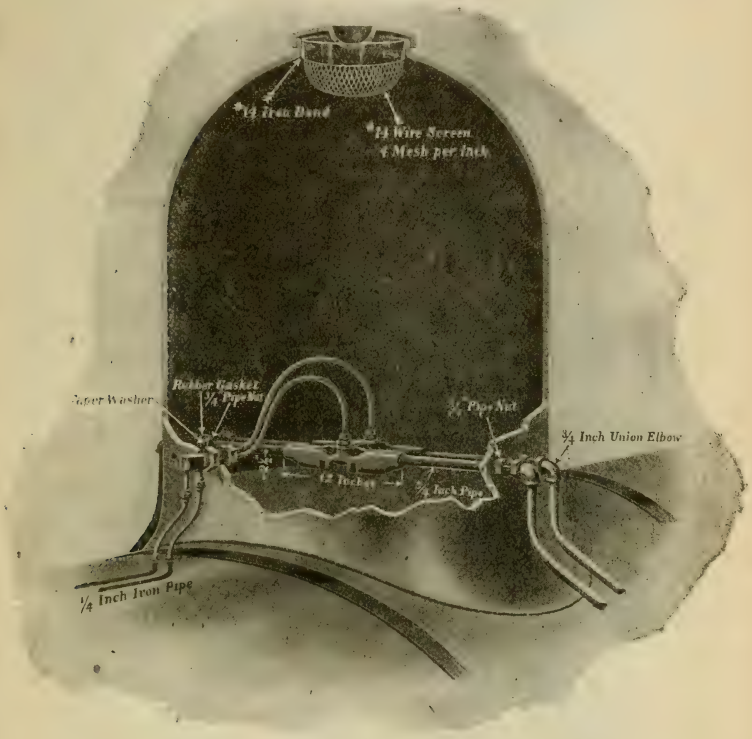


FIG. 6.
The "She" Sander, Showing Application to Sand Box.

It is simple in construction, being so arranged that the air nozzles are always out of the sand, and therefore they cannot become clogged when not in use.

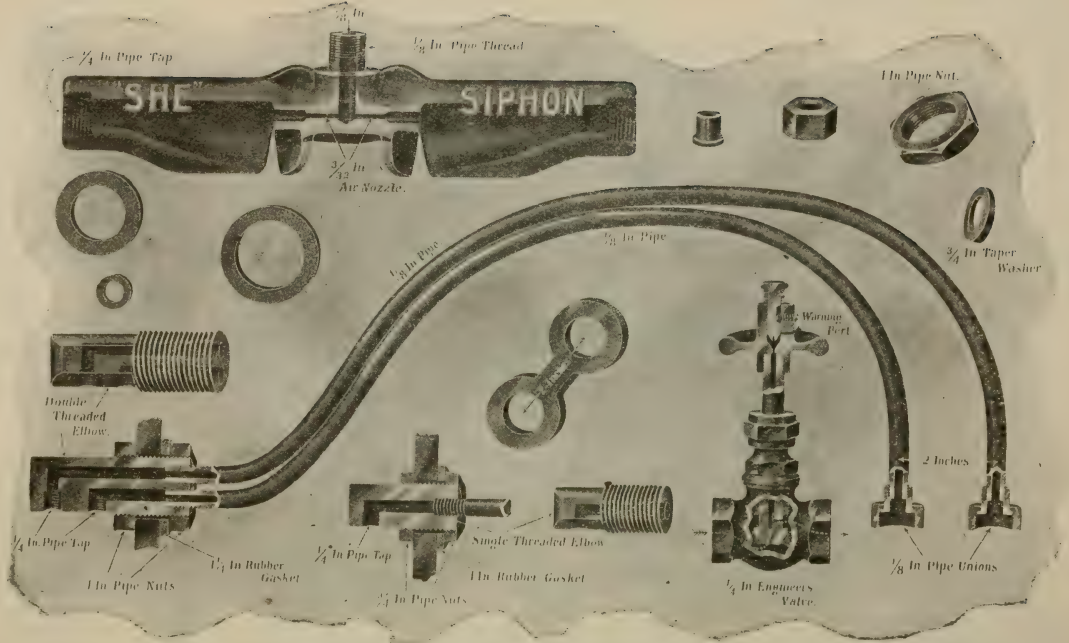


FIG. 7. Detail Parts "She" Sander.

The siphon being in the center of the sand box, where the sand is always the driest, it can be recommended for service where sand is apt to become damp and bake in the box.

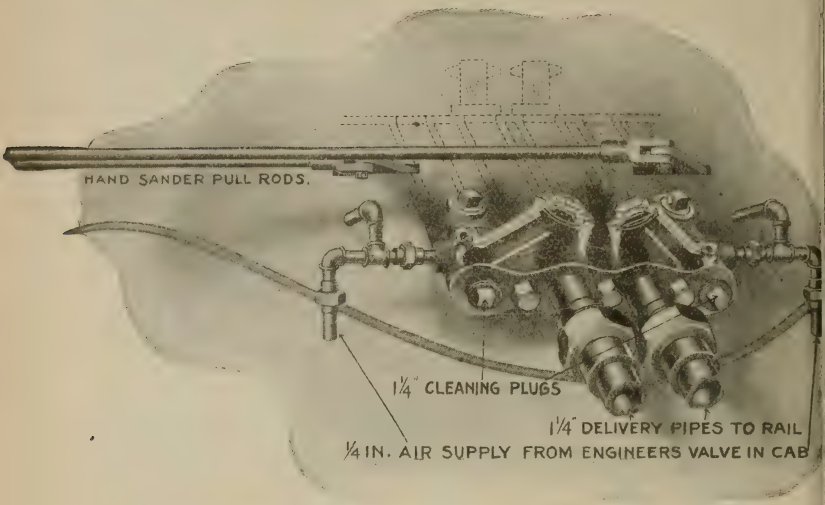
The sand-pipes can be run around the brake heads, or inside of the engine frames, getting close contact to the drivers.

Fig. 7 shows the detail parts of the "She" locomotive sander.

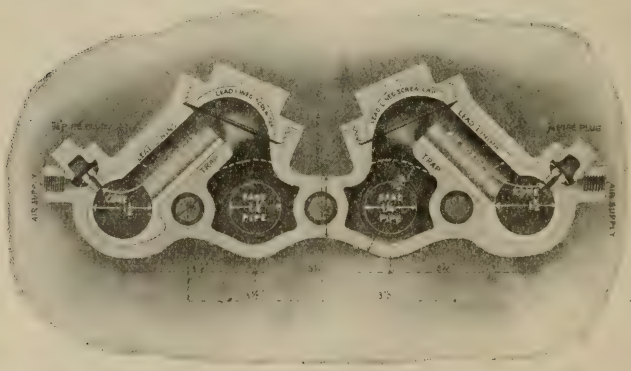
While it is only when the rail conditions are bad that the use of sand may be desired in making service stops, its use in emergency stops is very important as an additional means of securing a shorter stop.

Under emergency conditions it is especially important that every part of the brake or stopping equipment be applied at once and by one movement of the controlling brake mechanism.

VILOCO LEAD LINED LOCOMOTIVE SANDER



Most pneumatic sanders have the air nozzles located either within or below the body of sand in the trap which permits

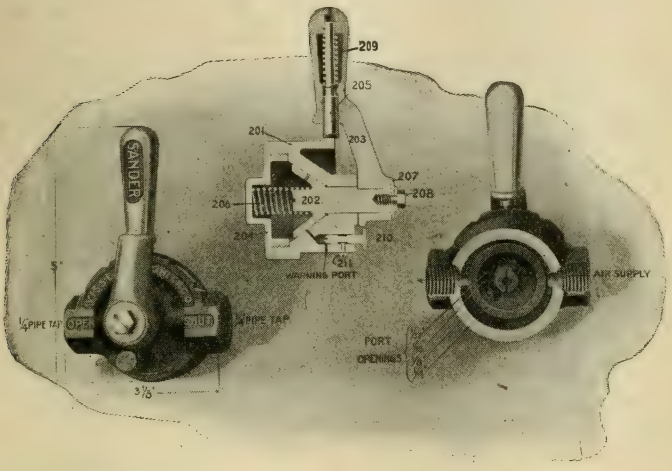


the sand to sift into the nozzle when air is shut off; then when air pressure is applied, the sand jams into the orifice

of the nozzle, making the sander inoperative, and often causing serious delay on the road. The Viloco has a top nozzle that it is claimed will not clog.

The accompanying illustrations show general view and sectional cut of traps for double sanders; single ones are similarly constructed.

"VILOCO" TYPE "K" ¼" ENGINEER'S VALVE



201. Valve Body.
202. Valve.
203. Handle.
204. Valve Cap.
205. Handle Latch.
206. Valve Spring.
207. Handle Washer.
208. Handle Cap Screw.
209. Handle Latch Spring.
210. Warning Valve.
211. Warning Valve Screw.

These sander traps are lead lined. The resilient properties of the lead resist the sand blast action, and for that reason the traps give very long service.

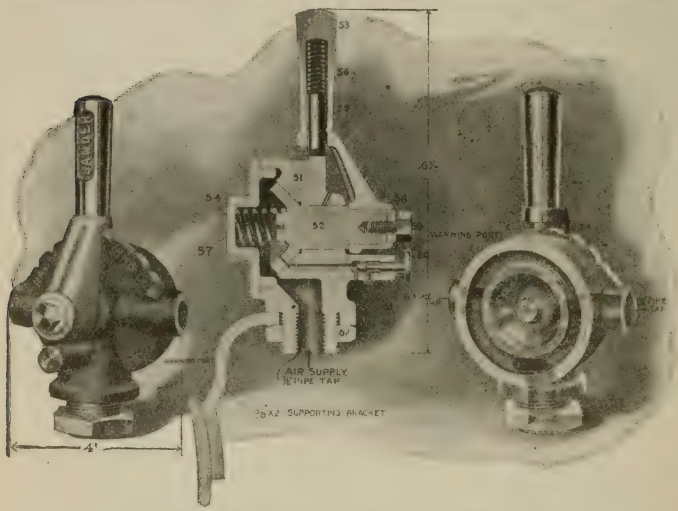
The use of a special engineers' sanding valve is recommended.

"VILOCO" TYPE "K" ¼-INCH SINGLE ENGINEERS' VALVE

The ¼-inch Engineers' Valve with warning port formerly used for the control of supply of air to single pneumatic

sanders has not proven satisfactory on account of breakage, and the fact that engineman cannot easily graduate the supply of air to the sander.

Illustration is shown of Type "K" ¼-inch Engineers' Valve which is interchangeable with the older valves. It has four graduations for the supply of air to the sander, with four notches on the quadrant corresponding to these graduations, and is fitted with a warning port which sounds immediately



Viloco Duplex Engineer's Valve.

the valve is open, should the engineman forget to shut off the valve when he can dispense with the use of sand.

DUPLEX ENGINEERS' VALVE WITH WARNING ATTACHMENT FOR OPERATING PNEUMATIC SANDERS

This valve has three graduated openings for both the front and rear sander. This is accomplished by means of ports of different diameter through the valve, and which ports register with notches on the valve quadrant, enabling the engineman to apply the sander lightly or to its full capacity.

The supply of air is taken from the bottom of the valve, which connection serves as a means of securing the valve to the supporting bracket attached to the boiler head.

The warning attachment operates immediately the handle is moved off the center notch of the quadrant and serves as a warning to the engineman that the sander is in operation. He may close the warning port by slight pressure on the button-headed valve 10, but as soon as his hand is removed to attend to other duties, the warning reminds him that the sander is in operation.

The Duplex valve takes the place of two of the ordinary valves formerly used for operating the double sander. It is strongly built, all parts exceptionally heavy with the view of its giving many times the service as compared with the small valves formerly used.

SHERBURNE'S ARRANGEMENT FOR AUTOMATIC SANDING

The simultaneous application of brakes and sand is best accomplished by use of the Sherburne automatic port placed in the Westinghouse engineer's valve and arranged as shown in Fig. 8.

This positively insures the application of sand during every emergency stop and without additional thought or action on the part of the engineer.

This automatic port can be used in connection with any pneumatic sanding device and can be applied at a small cost.

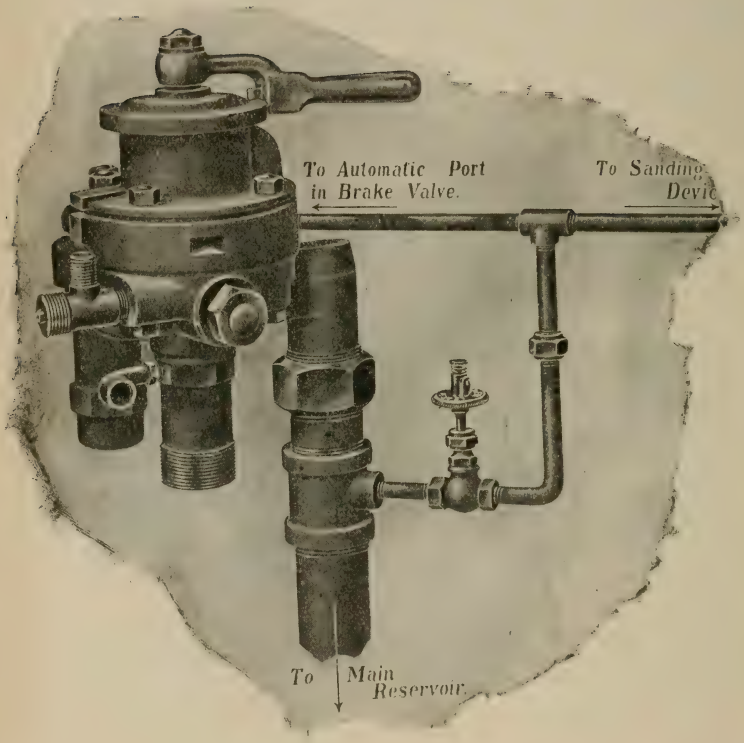


FIG. 8.

Sherburne's Arrangement for Automatic Sanding.

THE HUFF PNEUMATIC TRACK SANDER.

The Huff track sander is the invention of a locomotive engineer of long experience, and embodies new features suggested to him by his personal knowledge of many track sanders which have preceded this one.

The construction and operation of this sander are illustrated by Figs. 1, 2, 3 and 4, in which Fig. 1 shows the device as a whole; Fig. 2 each part separate of which it is composed; Fig. 3 its application to a locomotive and pipe connections thereto; and Fig. 4

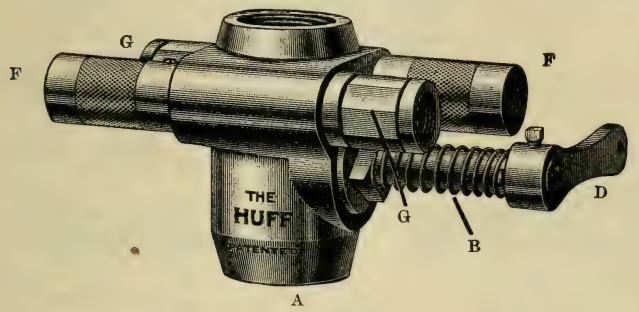


FIG. 1.
Huff Pneumatic Track Sander.

the engineer's valve in the cab, by which the mechanism is operated.

The body *A* is inserted into the old gravity sand pipe (which is otherwise undisturbed) at any convenient point, either above or below the running board. The compressed air supply pipes are connected at *F F*, and the sand delivery pipes are led off at *G G*. The lever *D*, operating the foot valve *B*, should be connected, by suitable means, to the cab, so that it may be under control of the engineer. A thin

sheet steel partition is inserted into the old sand pipes, extending from the dome down to the Huff device, forming a junction with a bridge in the device; this is to facilitate blowing out possible obstructions in the sand delivery pipes, as will be referred to later. Each of the two feed tubes *F* contains an air adjusting tube *H*, which, in turn, contains in one end the bridge

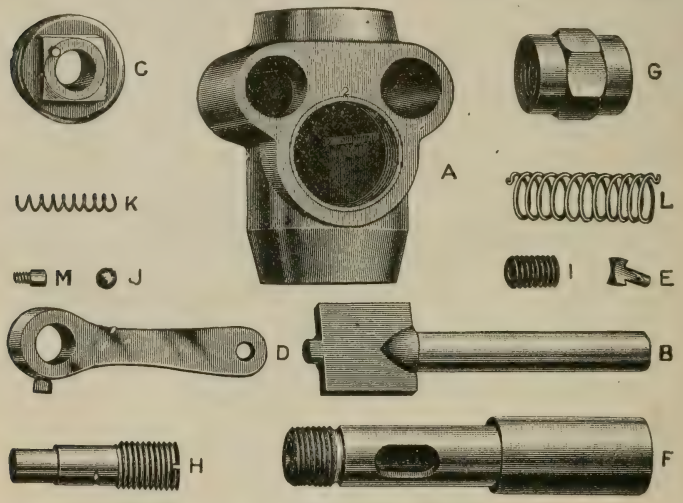


FIG. 2.
Detail Parts, Huff Pneumatic Track Sander.

E, in the opposite end the adjusting screw *I*, and between them the ball valve *J* and the spring *K*. This tube *H* is kept from turning in the feed tube *F* by the set screw *M*. The body *A* is fitted with a foot valve *B*, forming its floor, and so connected, as has already been said, that it can be worked from the cab. The stem of this foot valve *B* passes out through the nut *C*, and is encircled by the spring *L*, which tends to

keep the foot valve normally closed. When the device is being used as a double sander the slots in the feed tubes *F* should face each other. When in use as a single sander one tube may be revolved until its slot is blanked against the wall of body *A;* the tubes *F* may be firmly held in any position by the hectagon nut *G*.

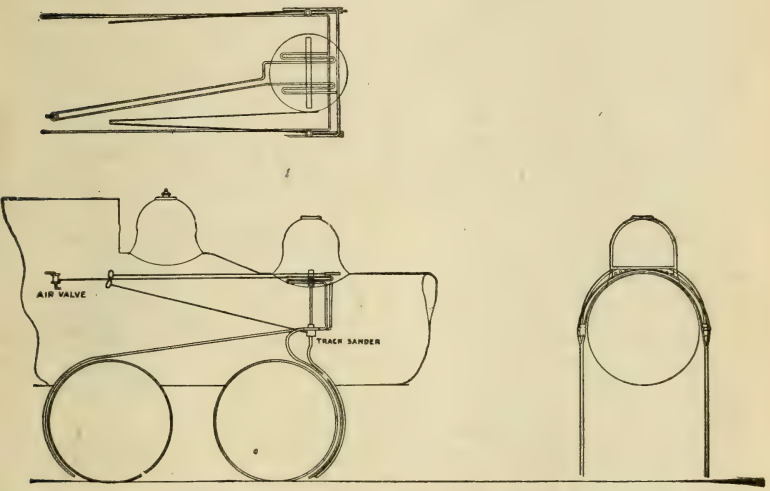


FIG. 3.
Huff Pneumatic Track Sander.
(Showing Application and Pipe Connections.)

The method of connecting the compressed air supply pipes from the engineer's sanding valve (see Fig. 4) to the feed tubes *F F* in body *A* is ordinarily the same as in other pneumatic track sanders; but, if it is desired to employ heated compressed air (which would be a great advantage in cold countries), the air pipes may be led to coils located over the boiler, under

the sand box (as shown by Fig. 3), and thence to the feed tubes *F F* of the body *A*.

The ordinary current use of the Huff track sander does not call for any further explanation, but it is desirable to refer to some of the methods of working in the emergency of one or another of the sand pipes becoming inoperative on account of obstructions. In that event the engineer may, while the engine is still running, close the main valve in the sand box, and open the foot valve, thus discharging the contents of body *A*, including any small obstructions which may have collected there; then by closing the foot valve and working the engineer's sand air-valve (in the cab) he may thoroughly blow out all the sand delivery pipes. In the case of an exceptionally obstinate obstruction in one of the pipes, which could not be dislodged by this treatment when the engine was running, it would still be possible, when the engine had stopped, to follow another course, by plugging the mouths of the free pipes, and concentrating the full force of the air pressure on the obstruction in the remaining pipe.

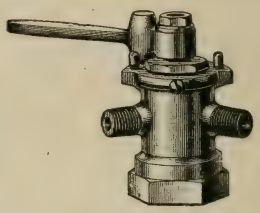


FIG. 4.
Engineer's Valve—Huff Pneumatic Track Sander.

Summarizing, it is claimed that this track sander embodies in its construction and operation the following advantages:

1. Minimum cost of application, and exemption from necessity of making any changes in the sand box itself or in the old hand-sanding apparatus under the sand box.

2. Feed adjustments so arranged as to secure both a minimum and a regular delivery of sand at the rail.

3. The foot valve feature results in a slight inward suction of external air through its joints, when air is applied (as such application creates a slight vacuum in body *A*); this tends to keep the sand loose in the body *A*, and to reduce the danger of clogging.

4. The reasonable probability of being able to blow out any ordinary obstruction while the engine is running; the possibility of being able to blow out and thoroughly dry all pipes after an engine comes in from off the road, and to insure everything being in working order for the next trip; the feature of being able to use heated compressed air in cold countries, or elsewhere, when desired.

5. In case of failure of the air supply, the foot valve may be fastened open, and the old hand sander used.

THE A-B-C TRACK SANDER.

A sander composed of but few parts is shown in Fig. 1. *A* is the connection to the sand box. *C* is the air connection leading from a small operating valve in the cab. *B* is the ordinary delivery pipe leading to the rail, and *D* is a loose tube at the opening of delivery pipe *B*.

Directions for Applying.--Cut the sand pipe just above the running board, or where sanders can be gotten at conveniently.

To Clean Out.--Remove plug in the top and pull out the loose tube *D*. Should air fail while on the

road, remove the loose tubes *D* and leave them out, using the ordinary hand sand lever.

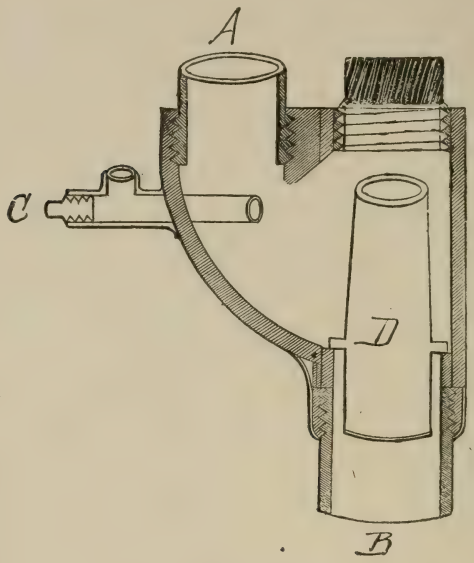


FIG. 1.
A-B-C Track Sander.

THE "MUDD" AIR SANDER.

This device is shown in detail by Figs. 1, 2 and 3, and is seen to be operated in conjunction with the original slide valve sand-lever device. One-inch standard pipe should be used for the forward delivery pipes, and one-half inch standard for the back-up.

For the forward motion, drill a one-half inch pipe tap hole through the base of the sand-box into the sand cavity to which the original pipes are attached,

the hole to be drilled between the original slide valve and the outer casing. This hole should be tapped out with one-half inch pipe tap, and one of the short

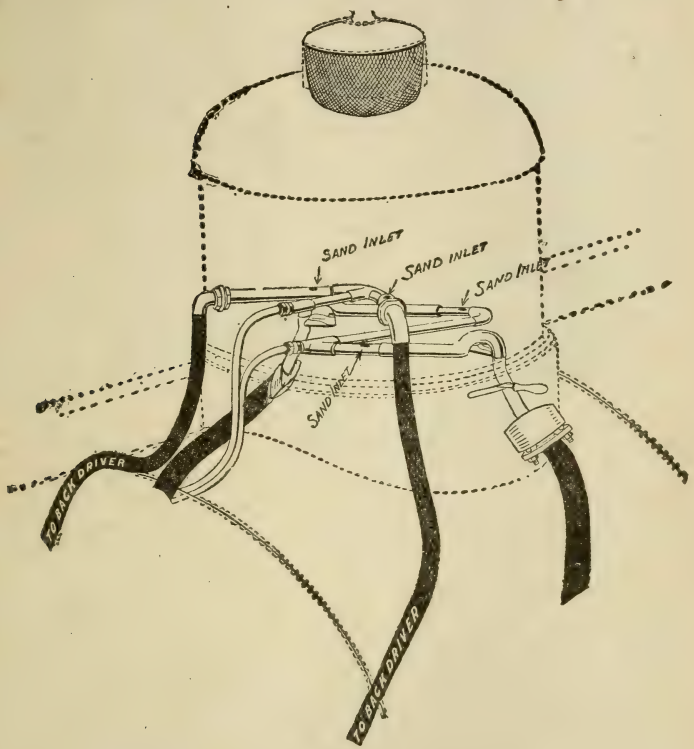


FIG. 1
The Mudd Track Sander.

nipples screwed in. Then drill a hole in the casing directly back of the center of the sand box, and as near the bottom as possible, through which place the air-pipe connection. The pipe that runs from the

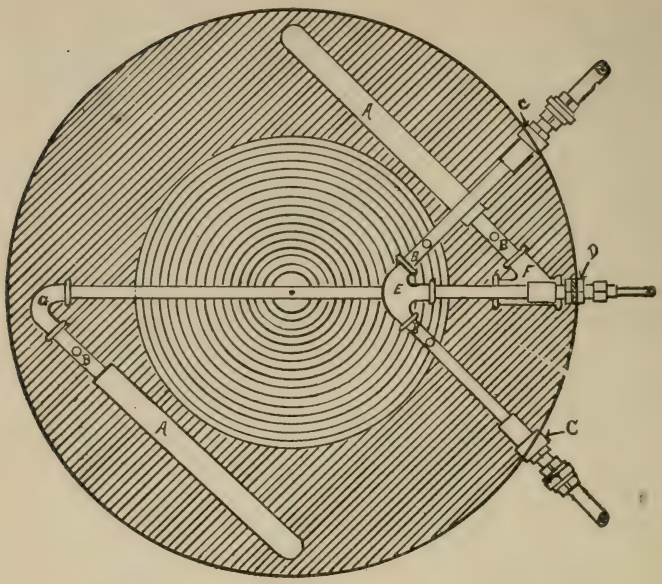


FIG. 2.
The Mudd Track Sander.
(Plan View.)

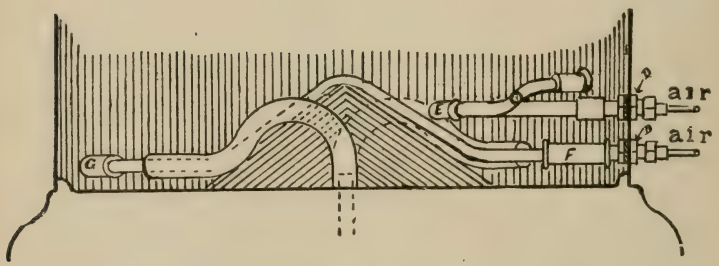


FIG. 3
The Mudd Track Sander.
(Side View.)

engineer's valves should be one-quarter inch copper pipe, and placed under the jacket.

There should be placed in the top of the sand box, as shown in Fig. 1, a one-quarter inch mesh netting to insure screened sand at all times.

The back-up sander should be placed directly over the forward delivery apparatus, and as near the bottom of the box as it is possible to get it.

The air pressure should be taken from the reservoir pipe attached to the engineer's valve.

MECHANICALLY OPERATED FIRE DOORS

It is generally conceded now that a mechanically operated fire-box door accomplishes everything claimed for it, and its adoption by the various railroads has been from a standpoint of better firing, greater efficiency, and more economy than can be obtained with the hand operated old style door.

The actual generation and utilization of the steam is entirely in the hands of the engine crew, and the greatest factor in economy in fuel has ceased to be as much a matter of skill and judgment in firing and running as it has of amiability and physical endurance. Assume that the maximum capacity of a fireman is 5,000 pounds (2½ tons) of coal per hour in continuous service. When he is compelled to deliver this amount of coal hour after hour, watch his share of signals, and be ever alert for the many other duties reverting to him, he may be so dissatisfied that his capacity for work is greatly lowered, frequently resulting in a poor steaming engine; or else he is so tired and indifferent that all existing instructions for careful firing are forgotten.

With heavy power on tonnage freight trains and heavy high speed passenger trains the intervals between firing are so short as to almost preclude any other method than that of standing on the deck and firing continuously on the major portion of the run. To do this successfully a policy of encouragement for the fireman is better than merely insisting upon economical methods of firing; for, if the encouragement is offered, the economies will follow.

It might be of interest at this point to mention that hand operation on the single or two-shovel method of firing requires much endurance, particularly so when the engine is working hard and the hand operated door must be pulled open against the exhaust. It has been found that, with an ordinary hook scale, as much as thirty pounds was registered in pulling the old type door against the exhaust of the engine. It also has been calculated that, for each ton of coal, containing 117 No. 4

scoopsful, delivered into the fire-box, 585 distinct movements were required of the fireman with the old style door; these movements were divided as follows:

1. Filling scoop.
2. Opening door.
3. Picking up scoop.
4. Delivering coal.
5. Closing door.

Taking as a basis of calculation an engine using 10 tons of coal per trip, with a No. 4 scoop holding an average of 17 pounds, with the old style door about 6,000 movements will be required to operate on the single shovel system. Basing the number of times the door is opened as 1,000, and assuming that each effort requires a pull of only 15 pounds instead of 30, he has actually lifted about 18,000 pounds in opening the fire door in addition to the 20,000 pounds of coal shoveled. It is not to be wondered at then that the firemen evade their instructions and hold the old style door open for several scoopsful, and perhaps then at ill-judged intervals or on light parts of the run.

The mechanically operated door eliminates this practice, since no mental or physical effort is necessary for the fireman to fire small quantities at short intervals. The pedal being in a natural position, his body movements as he procures and delivers the coal operate the door between each delivery. You can readily determine then where the saving in labor arises. Thus the movements per scoop of coal are reduced from five to two as follows:

1. Filling the scoop.
2. Delivering the coal.

Using the same calculation, the mechanically operated door reduces to 2,400 as against 6,000, the necessary movements, while the 15,000 pounds of wasted energy in opening the old style door by hand is entirely eliminated.

When more air than is necessary to produce complete combustion is admitted to the fire-box, as is the case when "slugging" or holding the door open for several scoopsful, it reduces the amount of steam generated in two ways: first, by reducing the temperature of the gases, and second, by increasing

the volume of gases and air which pass through the boiler tubes. The greater the volume which must pass through the tubes in a given time the greater must be the velocity, and, consequently, they remain in contact with the heating surfaces of the boiler for a shorter interval of time. Reducing the temperature of the gases and the time of contact with the heating surfaces reduces the amount of heat given to the water and, consequently, the amount of steam generated. It must be remembered that to obtain th best results from coal burned in a fire-box sufficient air must be supplied to burn both the coke and the gases. If the coke alone were to be burned, sufficient air could be admitted through the grates and coal by regulating the thickness of the bed of fire on the grates. To burn the gases, however, an additional amount of air is required. If, now, the thickness of the fire be so regulated, that sufficient air is admitted through the grates to burn both the coke and the gases, when fresh coal is supplied the fire will be too thin and will admit too much air after the gases have been consumed. Again, if the fire be kept so thin that sufficient air is admitted through the grates, it will be almost impossible to keep the fire level and free from holes when the engine is working hard, as the blast will carry the lighter particles of coal from the grates through the tubes unburned, thus permitting rapid inflows of cold air when and where it is least desired. It is evident then that sufficient air for complete combustion cannot be admitted through the grates alone, and that an additional amount should be admitted above the fire to complete combustion.

When air is admitted above the fire it must be introduced in such a manner that it will at once mix with the gases in the fire-box very completely, otherwise it will do more harm than good. If it is admitted in a large volume, as when the fire-box door is held open, the air will not mix with the gases, but will form a distinct current of its own. As the gases can only come in contact with the outer surfaces of this cold draft of air, they will not mix and, being cooled below their burning temperature, will pass away unconsumed.

It is of real necessity then that air must be admitted over the fire, and that it must be heated in order to mix readily

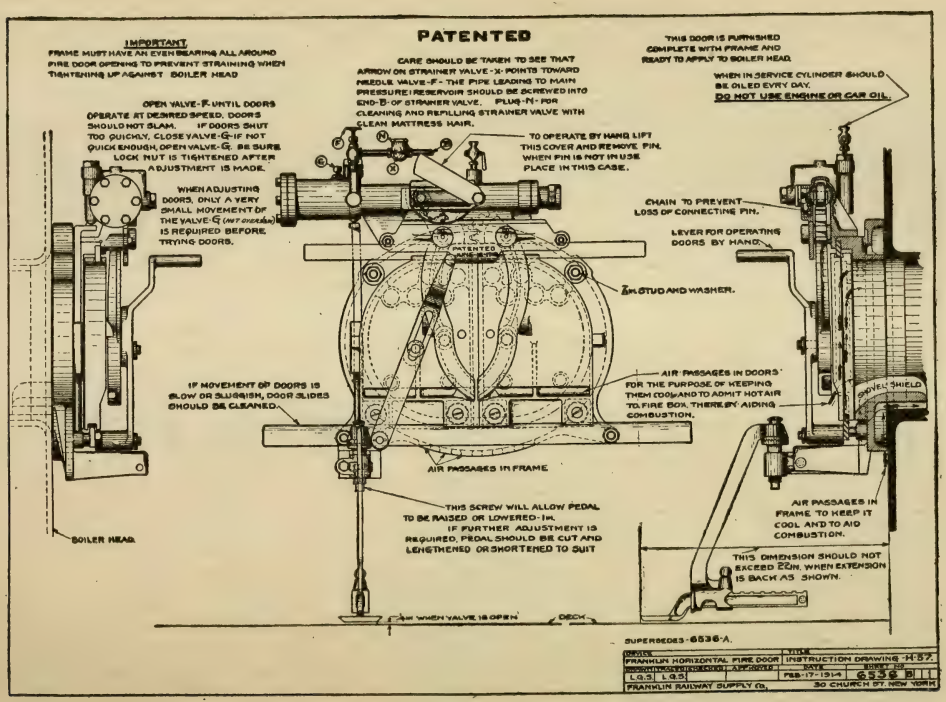

PATENTED
IMPORTANT
FRAME MUST HAVE AN EVEN BEARING ALL AROUND FIRE DOOR OPENING TO PREVENT STRAINING WHEN TIGHTENING UP AGAINST BOILER HEAD
OPEN VALVE-F- UNTIL DOORS OPERATE AT DESIRED SPEED. DOORS SHOULD NOT SLAM. IF DOORS SHUT TOO QUICKLY, CLOSE VALVE-G- IF NOT QUICK ENOUGH, OPEN VALVE-G. BE SURE LOCK NUT IS TIGHTENED AFTER ADJUSTMENT IS MADE.
WHEN ADJUSTING DOORS, ONLY A VERY SMALL MOVEMENT OF THE VALVE-G- (NOT OVER 1/64") IS REQUIRED BEFORE TRYING DOORS.
CARE SHOULD BE TAKEN TO SEE THAT ARROW ON STRAINER VALVE -X- POINTS TOWARD NEEDLE VALVE -F- THE PIPE LEADING TO MAIN PRESSURE RESERVOIR SHOULD BE SCREWED INTO END -B- OF STRAINER VALVE. PLUG -N- FOR CLEANING AND REFILLING STRAINER VALVE WITH CLEAN MATTRESS HAIR.
TO OPERATE BY HAND LIFT THIS COVER AND REMOVE PIN. WHEN PIN IS NOT IN USE PLACE IN THIS CASE.
THIS DOOR IS FURNISHED COMPLETE WITH FRAME AND READY TO APPLY TO BOILER HEAD.
WHEN IN SERVICE CYLINDER SHOULD BE OILED EVRY DAY.
DO NOT USE ENGINE OR CAR OIL.
CHAIN TO PREVENT LOSS OF CONNECTING PIN.
LEVER FOR OPERATING DOORS BY HAND.
PATENTED
7/8 STUD AND WASHER.
IF MOVEMENT OF DOORS IS SLOW OR SLUGGISH, DOOR SLIDES SHOULD BE CLEANED.
AIR PASSAGES IN DOORS FOR THE PURPOSE OF KEEPING THEM COOL AND TO ADMIT HOT AIR TO FIRE BOX, THEREBY AIDING COMBUSTION.
AIR PASSAGES IN FRAME
THIS SCREW WILL ALLOW PEDAL TO BE RAISED OR LOWERED 1". IF FURTHER ADJUSTMENT IS REQUIRED, PEDAL SHOULD BE CUT AND LENGTHENED OR SHORTENED TO SUIT
BOILER HEAD
AIR PASSAGES IN FRAME TO KEEP IT COOL AND TO AID COMBUSTION.
THIS DIMENSION SHOULD NOT EXCEED 22in. WHEN EXTENSION IS BACK AS SHOWN.
1/4" WHEN VALVE IS OPEN
DECK
SUPERSEDES-6536-A.
MODEL
FRANKLIN HORIZONTAL FIRE DOOR
TITLE
INSTRUCTION DRAWING H-87.
DRAWING OR SPECIFICATION NO.
L.Q.3. L.Q.5.
DATE
FEB-17-1914
SHEET NO.
6536 B
FRANKLIN RAILWAY SUPPLY CO.
30 CHURCH ST NEW YORK

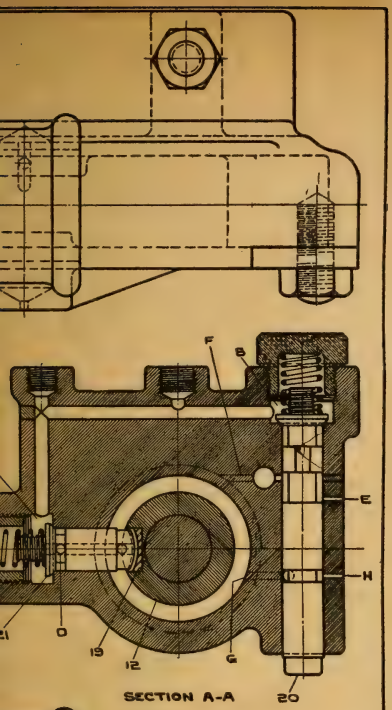
Fig. 1.
Franklin Fire Door—Horizontal Type.

with the gases. In the Franklin fire door this necessity is provided for in the hollow frame and hollow door plates. The cold air passes in over the deck and is heated as it passes up through the hollow frame and plates. Near the top of the upper door plates the heated air passes in over the fire through a number of small openings provided for the purpose. This provides the circulation of free heated air necessary to burn the gases. In this it can also be considered as a smoke consumer.

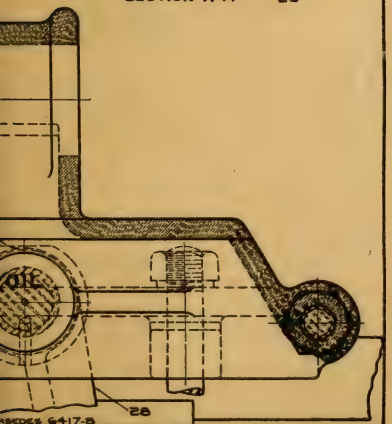
We now arrive at the conclusion that additional coal can be saved through the exclusion of cold air, since the more uniform the temperature in the fire-box the more perfect is combustion, and, consequently, a lighter fire and less coal. It is possible then to reduce the size of the scoop one or two numbers. By doing this if only 30 scoops are saved in 100 miles, based on a No. 3 scoop, averaging 15 pounds each, it would amount to 450 pounds per trip, or 67½ tons, for a year of 300 trips, at $2.00 per ton, these 100 engines would increase the saving $13,500. We can then safely estimate the saving on 100 engines through aiding combustion and the economies of the single shovel system of firing at $40,000.

Having considered some of the human and mechanical defects for fuel economy, we may well consider those adding to maintenance costs. It is easly understood that to maintain an even temperature in the fire-box, or "keep her hot," will prevent leakage of tubes and staybolts, as well as protect the fire-box generally. Having mentioned the volume and velocity of cold air rushing into the fire-box through holding the hand operated door open, it is easily seen why leakages are common. Tests have demonstrated that the temperature in a locomotive fire-box will drop as much as 600 degrees in one second, when the door is open; hence, the longer the opening the greater the drop in temperature and the more coal necessary to regain it. The repeated drops in temperature distort the junction of the tubes, staybolts and sheets beyond a capacity to return to their original tightness.

It being impossible to entirely eliminate opening the fire door it remains then to reduce the opening to the least possible time. With the old style door two or three minutes

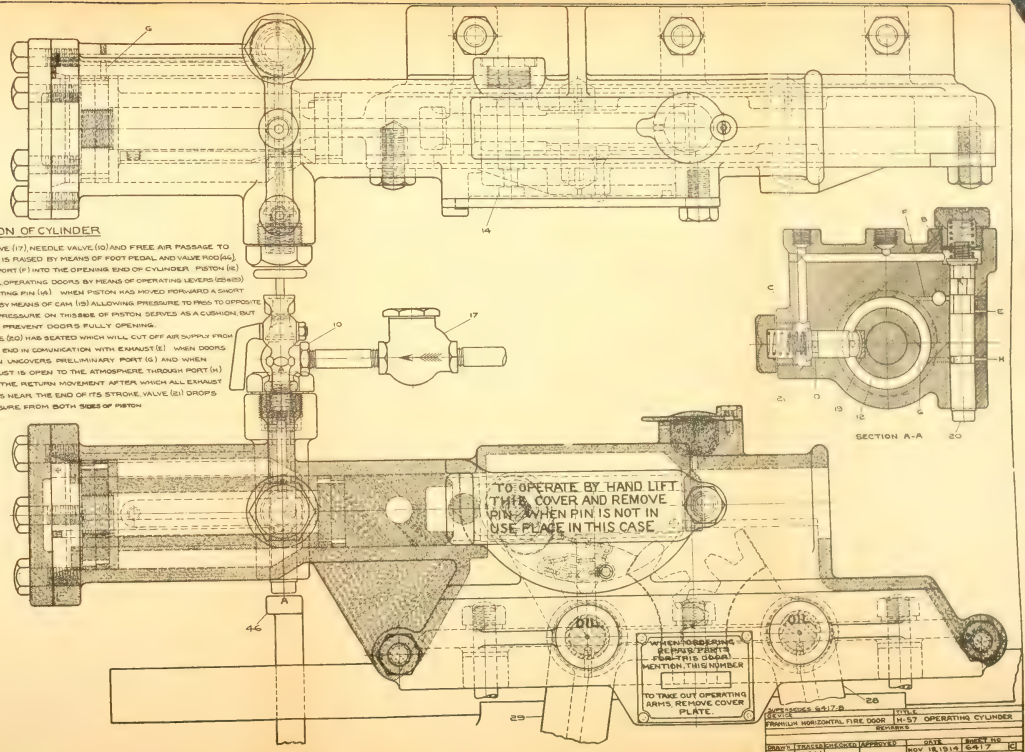


SECTION A-A



				TITLE	
LIN HORIZONTAL FIRE DOOR				H-57 OPERATING CYLINDER	
				REMARKS	
TRACED	CHECKED	APPROVED	DATE	SHEET NO	
M A W			NOV. 12, 1914	6417	C

KLIN RAILWAY SUPPLY CO. 30 CHURCH ST NEW YORK



OPERATION OF CYLINDER

AIR IS CARRIED THROUGH STRAINER VALVE (17), NEEDLE VALVE (10) AND FREE AIR PASSAGE TO CAVITY (B & C). WHEN OPENING VALVE (20) IS RAISED BY MEANS OF FOOT PEDAL AND VALVE ROD (46), AIR IS ADMITTED FROM CAVITY (B) THROUGH PORT (F) INTO THE OPENING END OF CYLINDER. PISTON (G) MOVES FORWARD TO THE END OF ITS STROKE, OPERATING DOORS BY MEANS OF OPERATING LEVERS (28 & 29) WHICH ARE CONNECTED TO PISTON BY CONNECTING PIN (46). WHEN PISTON HAS MOVED FORWARD A SHORT DISTANCE, THE CLOSING VALVE (21) IS RAISED BY MEANS OF CAM (19) ALLOWING PRESSURE TO PASS TO OPPOSITE SIDE OF PISTON THROUGH PASSAGE (D). PRESSURE ON THIS SIDE OF PISTON SERVES AS A CUSHION, BUT ON ACCOUNT OF SMALLER AREA WILL NOT PREVENT DOORS FULLY OPENING.

DOORS WILL REMAIN OPEN UNTIL VALVE (20) HAS SEATED WHICH WILL CUT OFF AIR SUPPLY FROM THE OPENING END OF CYLINDER, PUTTING THAT END IN COMMUNICATION WITH EXHAUST (E). WHEN DOORS ARE WIDE OPEN THE LARGE END OF PISTON UNCOVERS PRELIMINARY PORT (G) AND WHEN VALVE (20) IS CLOSED, PRELIMINARY EXHAUST IS OPEN TO THE ATMOSPHERE THROUGH PORT (H) UNTIL PORT (G) IS COVERED BY PISTON IN THE RETURN MOVEMENT AFTER WHICH ALL EXHAUST PASSES THROUGH PORT (E). WHEN PISTON IS NEAR THE END OF ITS STROKE, VALVE (21) DROPS FROM CAM (19) THUS SHUTTING OFF PRESSURE FROM BOTH SIDES OF PISTON.

for an opening and closing is not unusual. With the mechanically operated door the intervals between opening and closing will average four seconds for deliberate work and less, according to the experience of the operator. Thus the mechanically operated fire door can claim all the possible protection for the tubes, staybolts, etc., as well as the consequent fuel economy due to the exclusion of cold air and the ease for single shovel firing.

With coal containing slate or bone, or the common grades that lay in a sticky mass, it becomes necessary to frequently hook or rake the fire. This usually means a loss of five or more pounds while the fire door is open. The mechanically operated door can be closed on the rake handle and still give perfect freedom of movement. This allows the fire to be raked with a nearly closed door, excluding the cold air, and at the same time protecting the fireman from the intense heat and the engineer from the incandescent glare which may interfere with his observance of signal lights.

Another feature that had careful consideration in the construction of this type of fire door is that of insurance from accidents to engineman in the event of a burst flue. It being impossible to blow such a fire door open, it affords a protection to the engineer and fireman that places it in the class of safety appliances.

THE FRANKLIN FIRE DOOR

A brief description covering the operation of the Franklin horizontal door is shown in the accompanying detail cut of its operating cylinder.

The following description covers the operation in detail of the butterfly type of door as shown in Figures 3 and 4.

An important feature of this type of door is that it will not slam when opening or closing. It is so designed that when the door plates have opened the proper distance, the connecting link is on a dead center with the piston connecting pin and door bolt, which stops the door without the least jar or slam. When doors are closing, the air in the cylinder is exhausted past the small port in the cylinder head, the cylinder in reality being turned into an air dash pot. When doors are wide open the overhanging weight causes them to

close quickly about two-thirds of the way when they are stopped momentarily by the air cushion. When the doors reach this position the overhanging weight has been reduced to such an extent that the doors drop easily to the closed position.

The door is operated by air, and referring to Fig. 4, air is admitted through globe valve (33) and strainer valve (35) into the operating valve (36). When the foot of the operator is placed upon the tread (32), the valve (34) is raised from its seat, allowing the air pressure to pass through pipe (41), which connects the valve to the cylinder head, to the left end of the cylinder. The piston is carried forward by the action of this air pressure, and transmits its movement to the door through link (21), which is attached to the left hand door plate. The two plates are connected by intermeshing gear teeth. As the piston moves forward, the door plates are caused to rotate around the fulcrum pin (23) until they have uncovered the opening in the door frame, at which time the connecting link is straightened out so that the link connection on the left hand door has come into a direct line with the center of the door and the connection on the piston. This acts as an easy stop, making it unnecessary to have any other obstruction to stop the movement of the piston. When the foot of the operator is removed from the tread, valve (34) will seat, cutting off and exhausting the air supply from the cylinder. When the pressure is relieved from the piston, the weight of the doors will cause them to close automatically, at the same time returning the piston.

A hand operating lever (20) is provided so that the door may be operated by hand, if necessary, in case there is no air pressure; as, for instance, in the roundhouse or shop. A latch (40) is provided, which has two notches to engage the hand lever. The first notch, which is known as the "Smoke Latch," holds the door open about eight inches at the bottom to allow the admission of air to the fire-box while the locomotive is standing at stations. The other notch is so located as to hold the doors in the full open position.

The door plates are of hollow construction to allow the free circulation of air within them, and to admit heated air

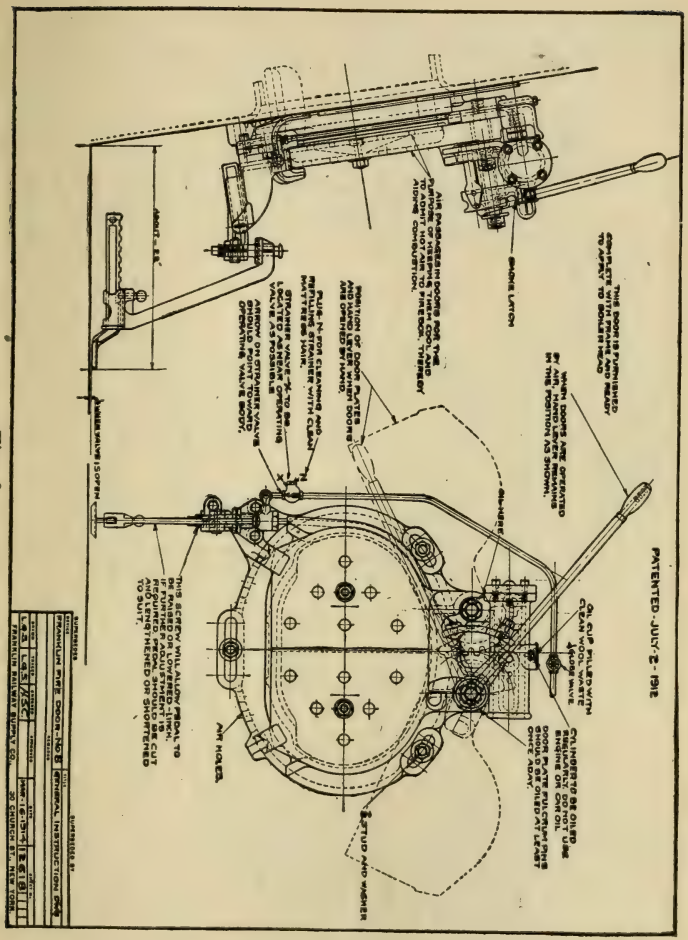
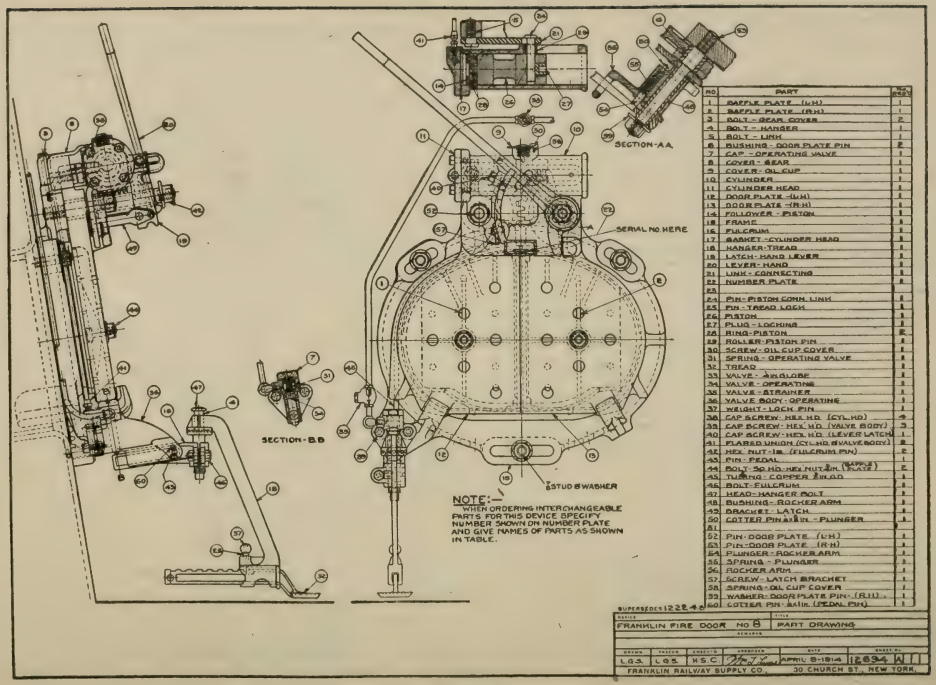


Fig. 3.

Franklin Fire Door—Butterfly Type.



NO.	PART	REQ'D
1	BAFFLE PLATE (L.H.)	1
2	BAFFLE PLATE (R.H.)	1
3	BOLT - GEAR COVER	2
4	BOLT - HANGER	1
5	BOLT - LINK	1
6	BUSHING - DOOR PLATE PIN	2
7	CAP - OPERATING VALVE	1
8	COVER - GEAR	1
9	COVER - OIL CUP	1
10	CYLINDER	1
11	CYLINDER HEAD	1
12	DOOR PLATE - (L.H.)	1
13	DOOR PLATE - (R.H.)	1
14	FOLLOWER - PISTON	1
15	FRAME	1
16	FULCRUM	1
17	GASKET - CYLINDER HEAD	1
18	HANGER - TREAD	1
19	LATCH - HAND LEVER	1
20	LEVER - HAND	1
21	LINK - CONNECTING	1
22	NUMBER PLATE	1
23		
24	PIN - PISTON CONN. LINK	1
25	PIN - TREAD LOCH	1
26	PISTON	1
27	PLUG - LOCKING	1
28	RING - PISTON	2
29	ROLLER - PISTON PIN	1
30	SCREW - OIL CUP COVER	1
31	SPRING - OPERATING VALVE	1
32	TREAD	1
33	VALVE - ANGLOBE	1
34	VALVE - OPERATING	1
35	VALVE - STRAINER	1
36	VALVE BODY - OPERATING	1
37	WEIGHT - LOCH PIN	1
38	CAP SCREW - HEX. HD. (CYL. HD)	4
39	CAP SCREW - HEX. H.D. (VALVE BODY)	3
40	CAP SCREW - HEX. H.D. (LEVER LATCH)	1
41	PLAIN WASHER (CYL. HD. & VALVE BODY)	8
42	HEX. NUT - 1/8 (FULCRUM PIN)	2
43	PIN - PEDAL	1
44	BOLT - SQ. HD. - HEX. NUT & PIN (BAFFLE PLATE)	6
45	TUBING - COPPER 1/4 O.D.	1
46	BOLT - FULCRUM	1
47	HEAD - HANGER BOLT	1
48	BUSHING - ROCKER ARM	1
49	BRACKET - LATCH	1
50	COTTER PIN & PIN - PLUNGER	1
51		
52	PIN - DOOR PLATE (L.H.)	1
53	PIN - DOOR PLATE (R.H.)	1
54	PLUNGER - ROCKER ARM	1
55	SPRING - PLUNGER	1
56	ROCKER ARM	1
57	SCREW - LATCH BRACKET	1
58	SPRING - OIL CUP COVER	1
59	WASHER - DOOR PLATE PIN - (R.H.)	1
60	COTTER PIN - 1/16 IN. (PEDAL PIN)	1

Fig. 4
Franklin Fire-Door No. 8 Butterfly Type

to the fire-box to aid combustion. A removable baffle plate is provided in order that it may be easily replaced in case of the plate burning out.

The operating pedal is adjustable. Tread (32) can be moved forward by one-inch notches to about seven inches by raising the latch (37) which will allow the tread to slide in the guide provided for that purpose. Side adjustment can be obtained by swiveling the entire pedal around the swivel pin (47). Vertical adjustment is also provided in the tread hanger bolt (4). With this bolt the tread can be raised or lowered one inch to give the necessary clearance between the deck and the pedal in case of the deck warping or shifting.

SHOEMAKER FIRE DOOR

The operation of the Shoemaker fire door is as follows:—

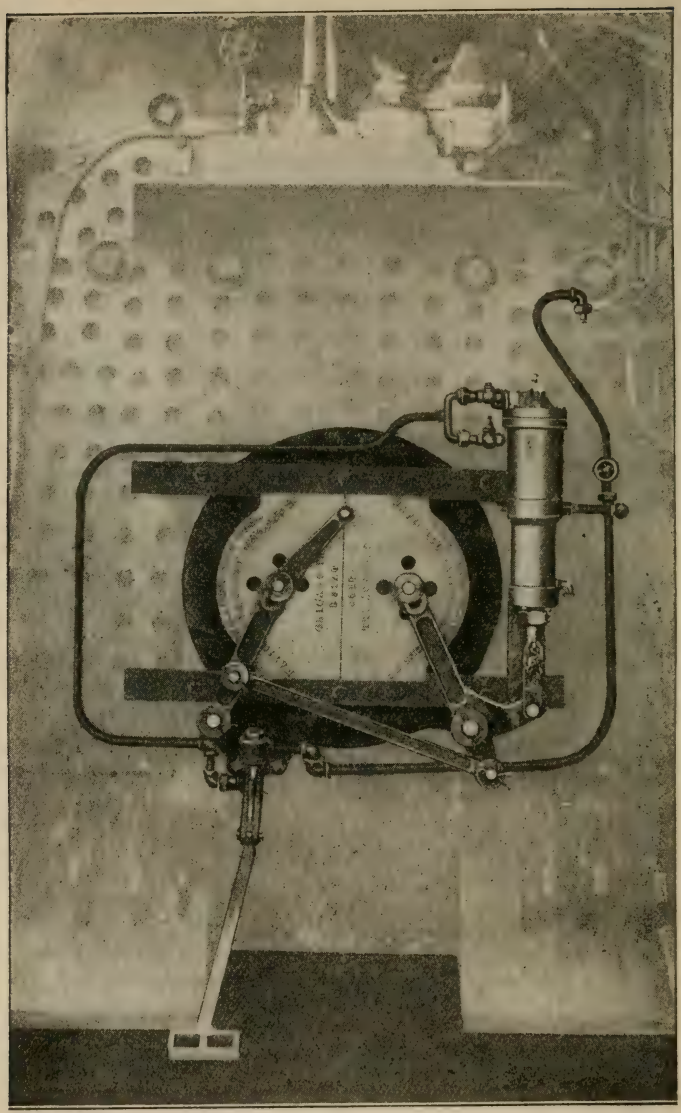
The opening of valve (from main air reservoir) blocks the air within chamber A of cylinder and between the larger piston T and smaller piston U, the greater area of upward piston pressure locking doors shut. The air is also blocked at B of foot-valve.

To open door, pressure on pedal C lifts the foot-valve off its seat, closes exhaust port D and forms a closed passage of air through the foot-valve and on through the admission valve E to the top side of the large piston head T. By reason of the now greater area of downward pressure (air pressure on both sides of piston T and on top side only of piston U), the piston is forced down.

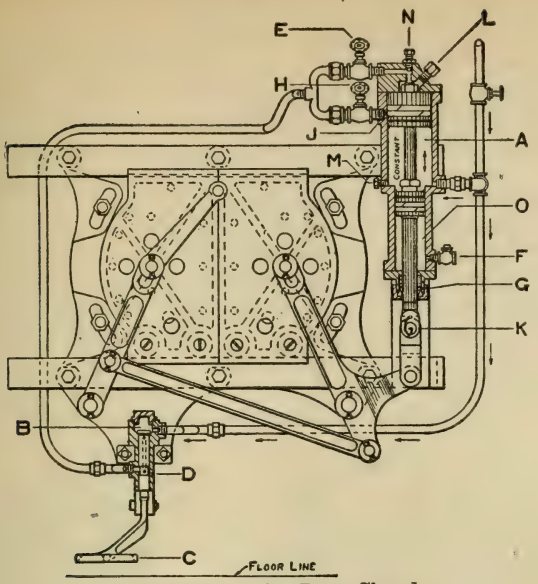
When the small piston head blinds port F and air cushion is formed in the bottom of cylinder until relieved by escape through stuffing box G. This prevents heavy jarring of the doors in opening.

To close the door—when pressure of the port on pedal C is withdrawn, foot-valve seats itself, again blocking the air at B; exhaust port D is opened, permitting a free escape of air from top side of large piston head T through exhaust valve H and the piston is again forced up by the original greater area of upward pressure in A.

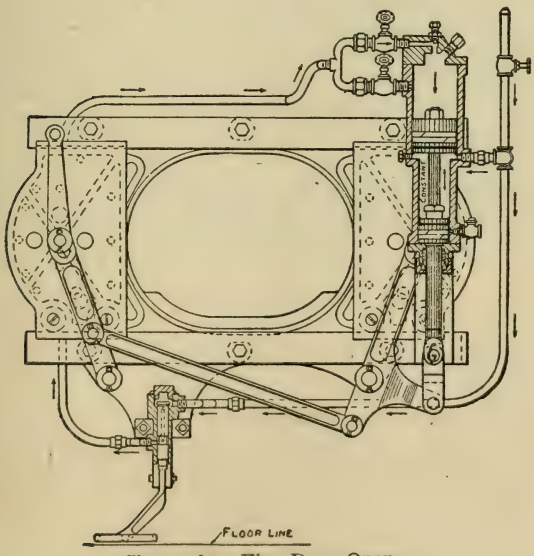
When the large piston head blinds port J, an air cushion is formed in the top of the cylinder until relieved by escape



Shoemaker Fire Door.



Shoemaker Fire-Door Closed.



Shoemaker Fire-Door Open.

through a small hole drilled in the inside wall of the admission valve E, which prevents the slamming of the doors in closing.

Plugs L and M are for oiling, and one may easily regulate speed of the opening and the closing door movements by adjusting screws N and O, respectively.

The following advantages are claimed:—

Positive action for both opening and closing from the simple differential piston air operation.

Noiseless movement—doors being positively air cushioned when either opening or closing; this also preventing abusive deterioration of the door mechanism.

Location of air cylinder and actuating (foot) valve away from the fire opening, avoiding the destructive effects of the intense heat on these sensitive parts.

Provision by adjusting screws for regulating speed of both door movements without affecting air cushions.

No delicate machinery to maintain. No gears or springs.

Every change to hand operation by removing self locking pin K.

Doors locked shut by air when not operating.

COAL PASSERS.

Included among the labor saving devices for the fireman is the coal passer. The coal passer is intended to assist the fireman by keeping the coal always at the front of the tender and also of an even mixture.

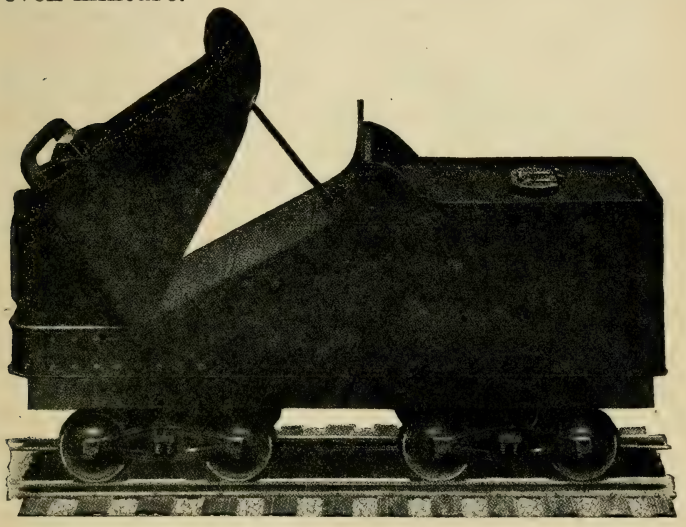


Fig. 1. Coal Passer Raised as in Operation.

The Ryan-Johnson coal passer herein described consists of a supplementary hopper D, shown in Figs. 2 and 3, which is connected to the bottom of the coal-pit by means of strong cast steel hinges as indicated at E, a tee piston-rod C is connected

to the back end of the hopper by the connection F and to the piston head B, which is provided with a buffing spring as shown in the cylinder A, which is placed in the water space through the tender-tank, the cylinder being provided with suitable release and drainage ports A and G.

By admitting pressure into the cylinder beneath the piston head, the T piston is actuated to its full stroke as shown in Fig. 3. The upper port being wide open to the atmosphere allows the pressure to escape before the spring comes in contact with

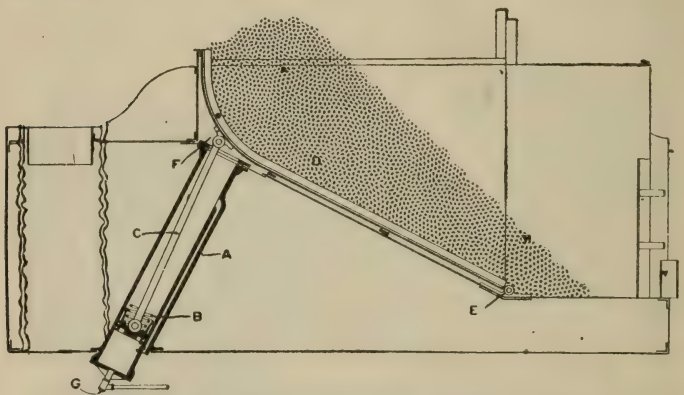


Fig. 2. Coal Passer Lowered in Normal Position.

the buffing plate; the buffing spring provided for on the piston head acts as a cushion and absorbs the balance of the shock. The hopper being raised in this manner, moves the fuel forward in the coal-pit. By closing off the pressure, the weight of the hopper forces it to return to its original position, the piston head on its downward stroke after passing the upper release port forces the entrapped pressure which now acts as a cushion,

out through the lower exhaust and drainage port G, which is only 3-16 of an inch in diameter. This movement allows the hopper to settle gradually to its normal position as shown in Fig. 2.

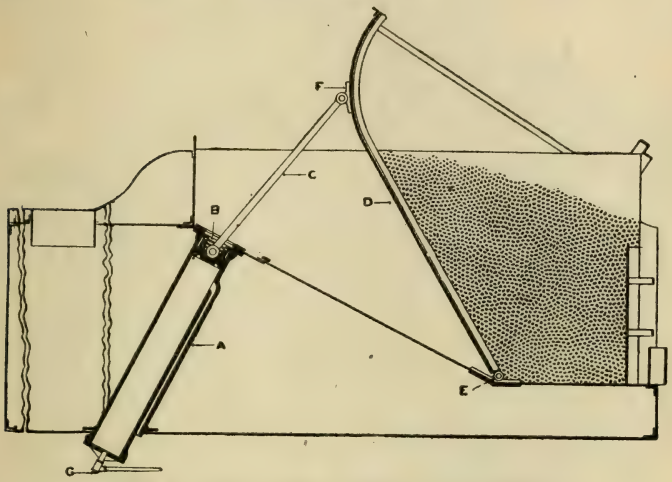
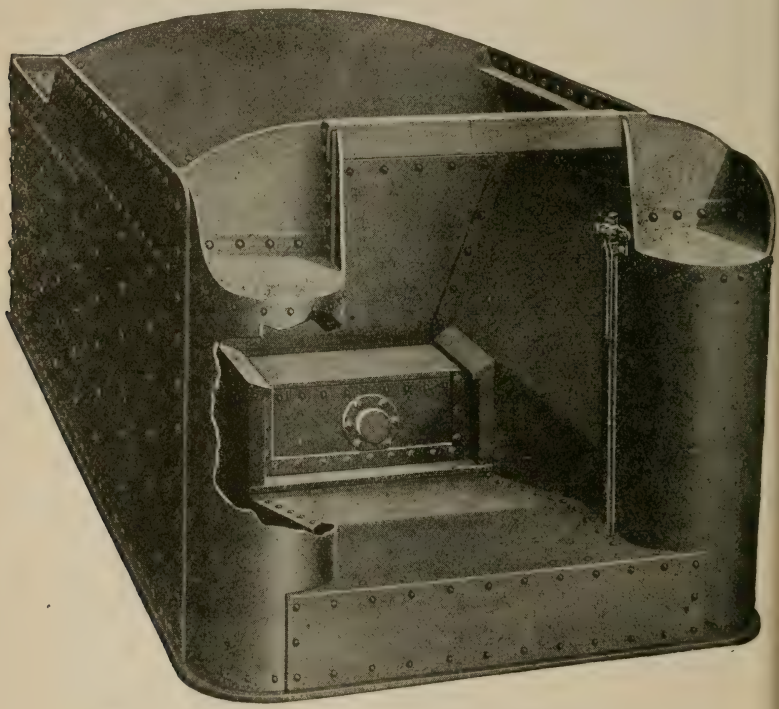


Fig. 3. Coal Passer Raised to Full Extent.

This drainage port G is a very essential factor, as it not only provides a drain for condensed water in the cylinder, but it also acts as a vent for circulating steam which is claimed to prevent freezing in cold weather.

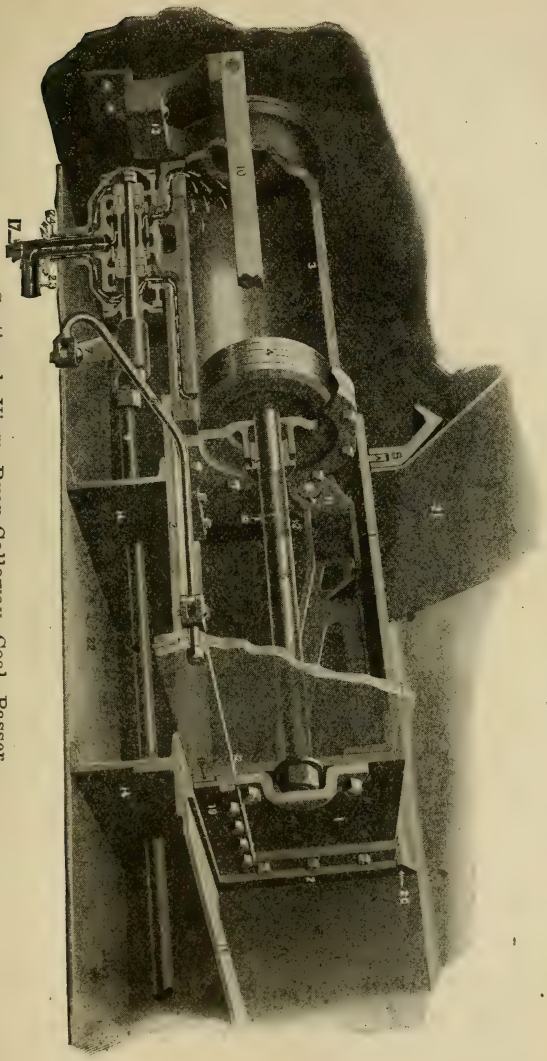
RYAN—GALLOWAY COAL PASSER

The reciprocating type of coal passer, as shown in accompanying cuts, consists of a plunger (1) and a trough (2), the former actuated by a piston rod (5), operated by an eleven-inch cylinder (3) and a highly efficient valve gear (6, 7, 8 and



General view of locomotive tender with coal passer.

9). The cylinder (3) and valve motion (6, 7, 8 and 9) are located near the bottom and just behind the back slope sheet (21) in the rear of the coal pit and in a space separated from the water space of the tender. The trough (1) is attached to



Sectional View Ryan-Galloway Coal Passer

and extends forward 24 inches from the front end of the cylinder (3) and is supported by channel irons (14) resting on the bottom of the tender (22). The plunger (1), which moves back and forth in trough (2), is held in line and supported by guide rails (10) and rollers (12); the latter operate in graphite bronze bushings to prevent corrosion. The plunger (1) fits snugly into the trough (2) and under the lower edge of the back slope sheet (21) and, in order that even the finest coal be prevented from working between plunger (1) and trough (2) or back slope sheet (21), packing strips (18), held in place by coil springs not shown in cut, are placed along the the bottom and sides of the plunger (1) and a similar packing strip (A) is placed along the lower edge of brace (B). Actuating rod (9) extends from valve lever (8) to a point just ahead of the coal gate on the left inside round of the tender and is operated by a neat and convenient lever attached thereto (not shown in the cut). The device over all is approximately five feet long, four feet wide and 18 inches high.

The normal position of the plunger, as shown in the illustration, is full ahead; as steam is admitted to the front end of the cylinder, the plunger is pulled to the back end of the trough and the coal drops down in front of it; when steam is admitted to the back end of the cylinder this coal is forced ahead within convenient reach of the fireman in normal firing position. By a clever arrangement of the valve motion a steam cushion is formed between the piston and cylinder head, thus avoiding the heavy shock that would otherwise ensue at each end of the stroke. The steam inlet pipe is placed inside of the exhaust pipe and, as the valve motion is so arranged that live steam is constantly entering the cylinder, it is impossible for the device to freeze up.

DESCRIPTION OF PARTS

1. Face and Top of Plunger.
2. Trough in which Pluger Operates.
3. Cylinder.
4. Piston and Packing Rings.
5. Piston Rod.
6. Piston Valve.

7. Valve Lever.

8. Valve Rod Connection to the Plunger.

9. Actuating Rod, Extending from Valve Rod to Control Lever Near Front of Tender.

10. Guide Rail to hold Pluger in Line, and Support for the Back End of Plunger.

11. Combined Brace and Roller Bearing.

12. Roller to Support and Guide the Plunger.

13. Bracket, Supporting Back End of Cylinder and Guide Rail.

14. Channel Irons Resting on Bottom of Tender and Supporting the Coal Passer.

15. Inclined Bottom of Coal Pit (the cut shows an interchangeable tender and the bottom of the coal pit may be either level or inclined, according to the height of the engine deck).

16. Side Sheet of Coal Pit.

17. Vent in Steam Pipe to Prevent Freezing and to Permit the Escape of Condensation.

18. Packing Strips, held against Surfaces by means of Coil Springs, to Prevent Coal from Working between Plunger and Trough.

19. Packing Strip Casing.

20. Overlap to prevent Fine Coal from Working between Plunger and Trough.

21. Sloping Back Sheet of Coal Pit.

22. Bottom of Tender.

A. Packing Strip.

B. Combined Brace and Packing Strip Casing.

THE LOCOMOTIVE FURNACE *

American railroads use about 135 million tons of coal annually at a cost of some 240 million dollars, or 12 per cent of their total operating expense.

Managers and motive power officials are well aware of the fact that a large part of this coal is wasted through imperfect combustion, and have been making strenuous efforts to locate the cause and apply a remedy.

Volumes have been written about methods of firing; about "bright, light and level fires"; about "cross firing"; about "single scoop firing"—most of them good methods and useful, when it is possible to follow them, but none of them sufficient to approximate perfect combustion in the fire-box of a modern locomotive.

Bituminous coal, which is used almost exclusively for locomotive purposes in this country, is not a homogeneous substance and cannot be successfully treated as such.

This fact has been appreciated by some engineers in designing furnaces for stationary power plants, but locomotive designers and builders have for the most part either ignored the characteristics of their principal fuel or have been influenced by the limiting conditions of weights, clearances and possible complications in fire-box construction, to such a degree that they have done comparatively little along this line, other than to encourage the use of a brick arch in order to get the maximum combustion efficiency possible under such conditions.

THE "SECURITY" ARCH IN THE ORDINARY FIRE-BOX

By "Ordinary Fire-box" is meant the rectangular furnace chamber built into the back end of a locomotive boiler. Its proportions are dependent entirely upon the size of grate required, the grate being bounded on the front by the flue sheet, on the back by the door sheet and on the two sides by the

*The following from a paper prepared by J. T. Anthony and John P. Neff, published by the American Arch Company, describing the advantages of the brick arch which is quite generally used, and of the Gaines Locomotive Furnace, now being applied by several railroads.

side sheets. This type of fire-box is always found to be as small as the grate proportions will permit, and is a wonder for simplicity and crudeness.

The only thing that can be done in the way of refinements for this type of furnace is to install a brick arch, which by virtue of its inclined position divides the furnace into two compartments, i. e., a furnace chamber, and a stingy combustion chamber, stolen from the furnace chamber space.

The arch accomplishes much, considering the limiting conditions. The flame travel is greatly increased, resulting in a certain degree of mixing of gas and air. The gas temperature is greatly increased as proven by many very authentic tests. The whole fire-box heating surface, limited in extent though it be, is made to transfer a much greater amount of heat to the water that surrounds it, due to the fact that the hotter flames are forced to impinge all the surface. The flues are protected from direct blasts of cold air from the open door or holes in the fire.

The net results of which are:

1st. Fuel economy of from 5 to 15 per cent for equal rates of work.

2nd. Increased boiler capacity of from 5 to 20 per cent for equal amounts of coal fired.

3rd. An abatement of smoke of about 50 per cent, other things being equal.

4th. A reduction in flue troubles under equally intelligent supervision.

The following illustrations in three pairs, Figs. 1 and 2, Figs. 3 and 4 and Figs. 5 and 6, are offered in an endeavor to describe the action in the ordinary locomotive fire-box under various conditions, with and without the brick arch.

The "Security" Sectional Arch, as illustrated in Figs. 7 and 8, is an advanced step in the development of the brick arch for the ordinary fire-box. The construction is plainly shown in the cuts. The features of superiority are:

1st. Security: portions cannot break off and fall into fire.

2nd. Sectional: proper size units for safe and easy handling.

Fig. 1.

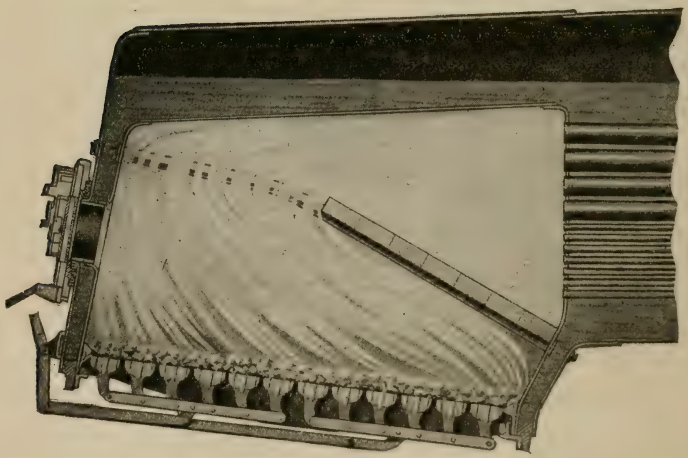


Fig. 2

Illustrating Effect of the Arch on Combustion. Note the White Hot Flame Above the Arch

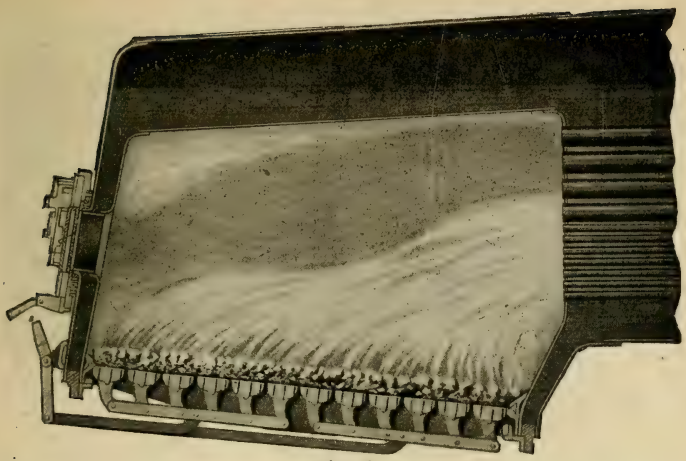


Fig. 3.

When the firedoor is opened an isolated shaft of cold air shoots straight to the flues. It chills them. They leak.

Fig. 4.

The Security Arch stops this. It compels the gases to mix and burn completely in the box. No cold air reaches the flues.

Fig. 5.
When a hole occurs in the fire an isolated shaft of cold air shoots straight for the flues. It chills them. They leak.

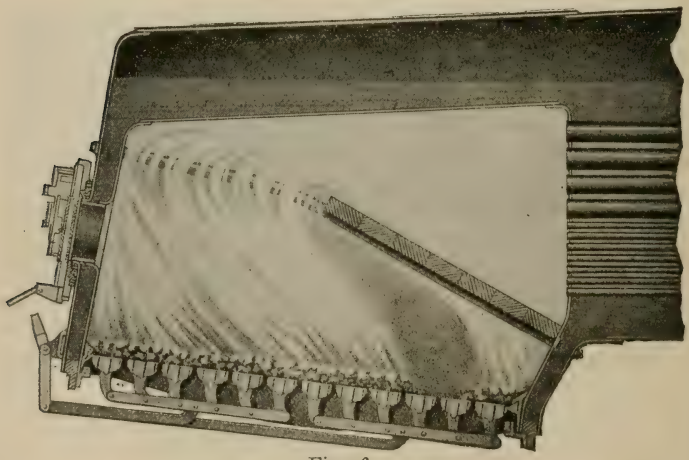


Fig. 6
This air is heated by the Arch mixing thoroughly in the flame. Nothing but the white hot flame can possibly reach the flue sheet.

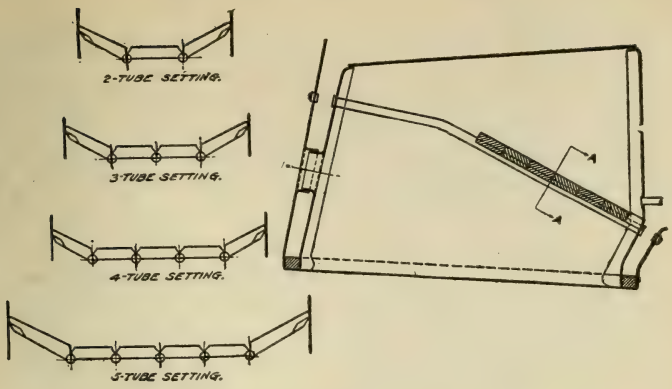


Fig. 7.

Security Sectional Arch showing arrangement for various widths of fire boxes and ideal spacings for Arch tubes.

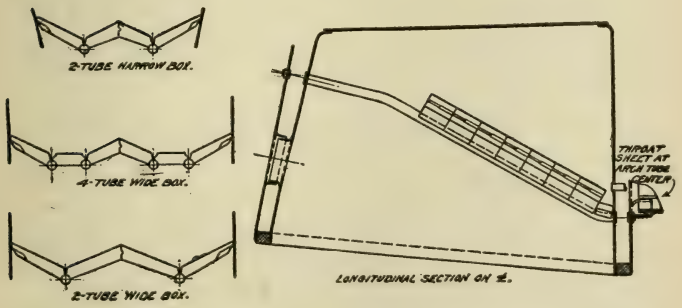


Fig. 8.

Security Sectional Arch showing arrangement for various widths of fire boxes and extreme spacing of Arch tubes made necessary by limited depth of throat.

3rd. Simplicity: no skill required to understand and install.

4th. Economy: portions may be removed for fire-box work without disturbing the whole.

It is, to the ordinary fire-box, all that an arch can be in the way of an aid to combustion, capacity and efficiency.

But the ordinary fire-box throws certain limitations around the matter of combustion. Let us see what can be done when unhampered by such limitations.

FUNDAMENTALS OF COMBUSTION.

Bituminous coal consists principally of fixed carbon which burns on the grate with little or no flame, and volatile matter which burns above the fuel bed with a long flame.

In order to approximate perfect combustion in the fire-box of our modern, high-powered locomotive, with ordinary firing, it is essential that the following provisions be made:

1st. A secondary air supply above the fire.

2nd. An intimate mixture of the volatile matter and the air.

3rd. Flame-way or combustion space sufficient to allow all gases to be completely burned before reaching the back flue sheet.

In an ordinary locomotive fire-box all the air is supplied through the grate. As this air comes in contact with the glowing coals of carbon at the bottom of the fuel bed, it gives up its oxygen, two parts of which readily unite with one part of carbon to form carbon dioxide.

The carbon dioxide thus formed passes on up through the fuel bed, and, unless accompanied by an excess of air, on coming in contact with the glowing coal at the top, it gives up part of its oxygen and is reduced to carbon monoxide.

When this carbon monoxide is brought in contact with oxygen or air which is heated to a sufficiently high temperature, it will be completely burned to carbon dioxide; otherwise it may pass off unburned, at a loss of about 10,000 heat units per pound of carbon, since carbon burned to carbon dioxide generates 14,600 heat units, while only about 4,400 heat units are produced when carbon is incompletely burned to carbon monoxide.

Bituminous coal contains from 25 to 50 per cent volatile matter which, being rich in hydrogen, has a very high heat value, generating from 12,000 to 21,000 heat units per pound of gas. These volatile hydro-carbons are driven off when green coal is thrown on the fire, and if supplied with a sufficient quantity of heated air (or oxygen) will readily ignite.

If there is no excess air above the fuel bed, they pass off unburned, producing smoke and leaving behind a deposit of soot in the fire-box and tubes.

If there is a partial supply of air, the hydrogen, having greater affinity for oxygen than the carbon, takes up the available oxygen from the air, forming steam, while the carbon is set free and either passes off in fine particles as smoke and soot, or combines with an insufficient quantity of oxygen to form carbon monoxide.

This shows the vital necessity for air above the fire, air being the medium through which oxygen is supplied; but the presence of air alone is not sufficient, for flue gas analyses often show incomplete combustion with large excess of oxygen.

When air at atmospheric temperature is admitted into the fire-box, it has to be heated up to the igniting point before its oxygen is available for combustion, and if it enters in a large shaft, as through an open fire door, it is possible for it to flash through the fire-box and into the flues before the igniting temperature is reached, in which case it hinders rather than aids combustion, and at the same time endangers the flues.

It is important that the air be heated, as hydrogen will not combine with oxygen below about 600 degrees Fahrenheit, nor carbon with oxygen below 800 degrees Fahrenheit.

It is also necessary to have an intimate mixture of the volatile matter and the air in order that every particle of carbon and hydrogen contained in the former may come in contact with the required amount of oxygen contained in the latter. In no other way can perfect combustion be obtained, yet this is a point that has been largely neglected.

It is very apparent that the flame-way or combustion chamber space should be long enough to give the gases time to mix and burn completely before striking the flue sheet, for

the flames are extinguished on entering the small fire tubes and combustion ceases.

The advantage of a combustion chamber has been appreciated by many and used to some extent; but most roads have, in the past, refrained from the use of the common, water-leg type of combustion chamber on account of the complications in construction and maintenance costs.

THE SECONDARY AIR SUPPLY

The amount of air needed above the fuel bed depends upon the composition and per cent of volatile in the coal, the rate of combustion, the efficiency of the gas mixing devices and the volume of the fire-box and combustion chamber, and varies from 20 to 35 per cent of the total air supply.

That the composition and per cent of volatile matter influences the air supply is very apparent. Since all the volatile matter burns above the fire, the per cent of air required above the fire will vary with the amount of volatile in the coal and on the proportion of hydrogen and carbon in the gases, other things being equal, as a pound of hydrogen requires about three times as much air for complete combustion as a pound of carbon.

As the rate of combustion increases, the fire usually becomes thicker and this increase in thickness of the fuel bed, by offering more resistance to the passage of air, tends to reduce the air supply above the grates at a time when it needs to be increased, owing to larger volume of volatile gases being distilled, and to the increase in the amount of carbon monoxide reduced from carbon dioxide in passing up through the thicker bed of coals.

The efficiency of a gas-mixing device has a direct bearing on this secondary air supply. If it were possible to get a perfect mixture of the combustible gases with the air, the theoretical amount of air required would be sufficient to assure each molecule of methane, carbon monoxide, hydrogen or other combustible meeting with its needed oxygen; but in actual practice such a condition is impossible and it becomes necessary to supply an excess of air in order that each molecule of combustible gas may readily find its mede of oxygen in the short time available, for the gases linger in the fire-

box only the fractional part of a second even under medium rates of combustion, and when the rate is high, the time is almost nil.

Increase in fire-box and combustion chamber volume promotes combustion by lengthening the flame path and giving the gases more time to mix and burn. If the fire-box is shallow and the combustion chamber restricted, the flame-way and time are reduced, so it becomes necessary to increase the speed of combustion in order to burn the gases completely before they enter the fire tubes, and this can only be accomplished by increasing the air supply.

When a volume of combustible gas is brought in contact with oxygen (or air) heated to the proper degree, a chemical reaction (combustion) begins with a high velocity, but as the reaction continues, the velocity becomes less and less and combustion becomes more difficult. This is due to the fact that as combustion proceeds, the amount of burned gas increases while the unburned gas and oxygen decrease, and the mass of burned gas mixing with the combustible gas and oxygen tends to separate them, makes their union difficult, and retards combustion.

A pound of carbon when burned will give off 14,600 heat units. The amount of heat given off is unaffected by the speed of combustion, if the combustion is perfect; but when we wish to increase the degree of heat, or raise the temperature, it is necessary to increase the speed of combustion. This is accomplished by supplying more air, either by carrying a lighter fire, thereby reducing the resistance to the passage of air, or by increasing the draft—which should be avoided, if possible.

THE GAINES LOCOMOTIVE FURNACE

The Gaines Combustion Chamber consists essentially of a fire brick bridge wall extending across the fire-box (see Fig. 9), forming a combustion chamber between the wall and flue sheet, the tubes being shortened and the fire-box lengthened sufficiently to admit of this application, while the grate remains normal. The bridge wall is carried by a casting extending across the fire-box and secured to the mud ring at

each side by studs. This casting also supports the grate frames and the buck stays in the rear, which prevent the wall from toppling. The floor of the combustion chamber is made of cast or wrought iron plates, protected with fire brick to prevent burning out, and in order to take care of cinder accumulation in the combustion chamber, a spark hopper is provided in the center, the floor being given sufficient pitch to cause all accumulation to drain out when the hopper is opened.

The bridge wall is built up of special fire brick of such size as can be easily handled, and in these brick are cored air passages matching the openings in the carrier casting. The size and number of the air ducts vary, according to the factors which determine the amount of air needed above the fuel bed.

When the locomotive is operating, the wall becomes white hot, with the result that the outside air, being forced through the air ducts, under the influence of the pressure drop in the fire-box, is heated up quite appreciably before being discharged into the fire-box. As it issues from the ducts near the top of the bridge wall, the heated air comes in contact and mixes with the combustible gases that are forced to pass up over the top of the wall. Combustion begins the instant the air comes in contact with the gases, and the reaction continues until the gases are all burned or the flames are extinguished on entering the tubes.

In Fig. 9 the wall is shown extending up to within 15 inches of the crown sheet, as in practice it has been found desirable to carry the wall as high as possible without obstructing the draft; this increases the baffling effect and promotes the mixture of the air and gases.

Aside from its aid to combustion, this wall also offers complete protection to the flues. The combustion chamber being made thoroughly air-tight, it is very evident that it would be impossible for any cold air to reach the flues through a hole in the fire or through an open fire door, for air entering through either of these places would be forced to pass up over the wall and come in contact with the flames, hot gases and incandescent brick, thereby being heated up and rendered harmless before reaching the flues.

The first locomotive equipped with this device has been

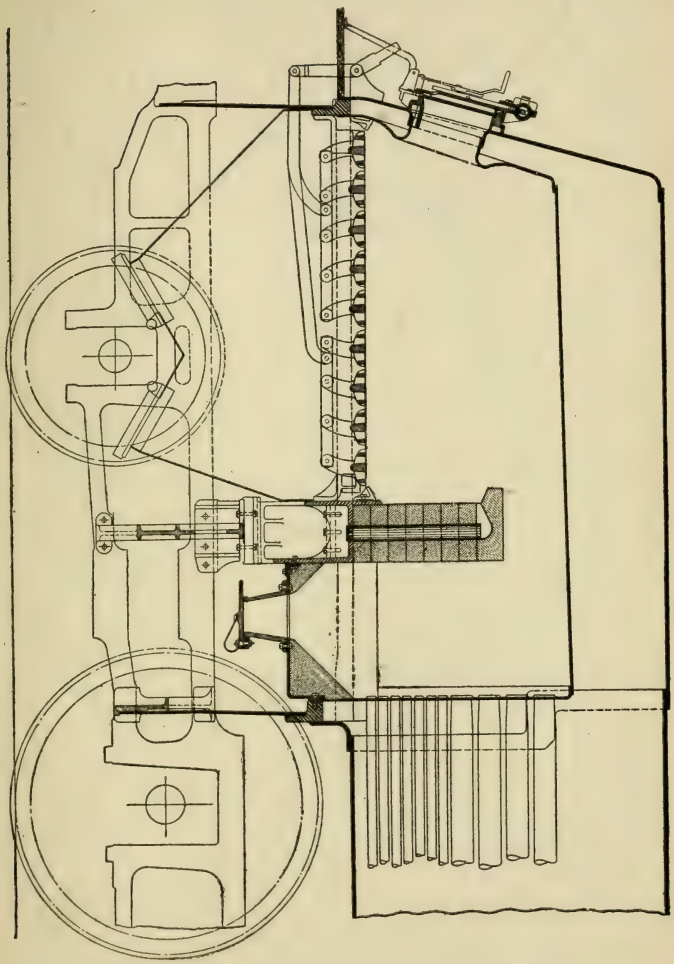


Fig. 9.

Gaines Combustion Chamber applied to a Pacific type locomotive. Equally well adapted to other engine types, particularly in bad water districts where arch tubes cannot be used.

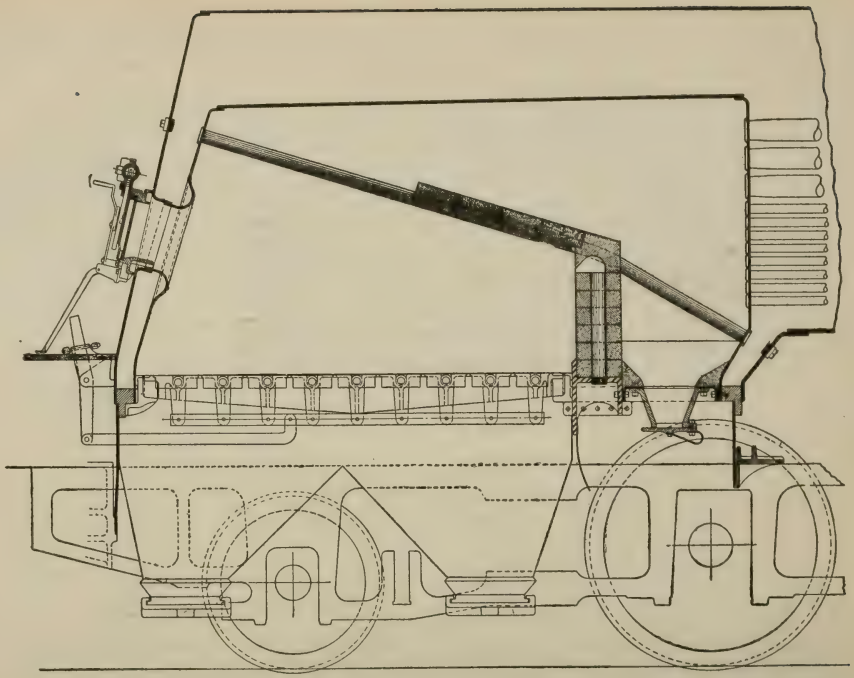


Fig. 10.
Gaines Combustion Chamber combined with Security Arch and known as Gaines Locomotive Furnace. Shown applied to a Mikado engine. Equally well adapted to Consolidations. Mallets, Switchers and Freight Pacifics.

in service about four years, and it has proved an unqualified success in improving the steaming qualities, saving fuel, reducing smoke and cinder nuisance and prolonging the life of the flues. The success of the first installation was followed by the application of the device on several Eastern roads. All locomotives so equipped have given good service and in several ways have shown to advantage over similar engines equipped with arches; but the fact that arches of the Security type were giving good service and possessed many advantages over other devices, could not be lost sight of, and after some trials, the Gaines Combustion Chamber and Security Arch were combined—the combination as shown in Fig. 10 being known as the Gaines Locomotive Furnace.

This combination is ideal, possessing all of the advantages of the Gaines wall and Security Arch, with none of the disadvantages.

The arch tubes add to the effective fire-box heating surface and increase the circulation.

The addition of the arch back of the wall doubles the flame-way without increasing the length of the fire-box, increases the effectiveness of the heating surface at the back of the fire-box, increases the mixing of the air and combustible gases, and, on account of the longer flame-way, gives the gases longer time to burn, thereby reducing the amount of excess air required.

It is often impossible to apply arch tubes to ordinary fire-boxes with shallow throat sheets on account of the lack of firing clearance, and in many cases it is impossible to keep the bottom tubes open because of slag and cinders going over on top of the arch and plugging them up.

The bridge wall does away with these troubles. A deep throat sheet is no longer necessary for firing clearance under the arch, and any cinders or slag that pass over the bridge wall fall into the hopper from which they are easily drained at the end of the run.

A locomotive furnace of the type shown is especially adapted to overfeed stoker firing, providing, as it does, a flash wall to fire against, with an arch to baffle and hold the fine particles of coal in the fire-box until they are mixed with the

heated air and burned, thereby eliminating smoke and cinders and keeping the flues and tubes free from all accumulation.

The furnace is shown in Fig. 10 as applied to a Mikado locomotive; but it is equally well adapted to Pacific, Consolidation, Switcher or Mallet locomotives.

A Mallet locomotive fire-box with a barrel combustion chamber is shown in Fig. 11. While this type of combustion chamber is not necessary with the Gaines furnace, it was used in this case to reduce the excessive length of flues and to balance the weights on drivers, it being impossible to carry the mud-ring forward to the flue sheet without interfering with the reversing gear.

The barrel combustion chamber has met with much opposition in the past owing to its complications and cost of maintenance, but in recent years much of this trouble has been eliminated by the liberal use of flexible stays and by welding the seams.

The large dead water space beneath the barrel has also been a source of much trouble, but this may be easily overcome by applying arch tubes as shown.

Here the five 3½-inch tubes add 70 square feet to the effective fire-box heating surface, evaporate about 4,000 lbs. of water per hour, and produce quite a circulation in an otherwise dead water space, thereby reducing the variations in temperature around the barrel, making the expansion and contraction uniform and eliminating leaky seams and stays.

A study of the illustration brings out the fact that the application of this furnace permits of great flexibility in design and location of the fire-box with respect to the wheel arrangement.

The conventional type of fire-box on an Atlantic, Pacific or Mikado locomotive is always located back of the rear driver, this construction being necessary in order to get the deep throat that is required to keep the grate line well below the bottom flues. On large Pacific and Mikado locomotives, excessive flue lengths or the use of barrel combustion chambers necessarily follow this practice.

In trying to keep the center line of the boiler down, the builders are forced to bring the fire-box close to the top of

the frames and trailer wheels; this results in shallow ash-pans that burn out easily, complicated wheel housings, and insufficient air openings.

On Consolidation and Mallet locomotives, the fire-box being located above the drivers, the grates are placed as low as the wheels will permit—scant attention being paid to the ash-pan—while the required firing clearance between the grates and bottom flues is obtained by raising the center of the boiler to the necessary height.

The Gaines furnace, by its method of construction and application, does away with most of the bad features mentioned. Fig. 9 shows the grates of a Pacific type locomotive raised up on a line with the belly of the boiler, the mud-ring being carried forward above the drivers and cradled in the center, the depth of the throat being reduced to a minimum. This permits of the boiler being brought lower on the frames without impairing the ash-pan.

In Fig. 10 the fire-box of a Mikado locomotive is carried forward above the rear driver; this location of the back flue sheet reduces the flues to a reasonable length without the aid of a barrel combustion chamber. The shallow throat permits the boiler to be kept well down on the frames without crowding the ash-pan, while at the same time a fire-box volume, much in excess of the ordinary, is obtained.

On the Mallets shown in Fig. 11 the grates are also located above the belly of the boiler. This construction allowed the boiler to be lowered 6 or 8 in. without harm to the ash-pan, while a fire-box of exceptionally large volume and long flame-way was obtained.

Where drivers of very large diameter are used, a construction similar to that illustrated in Fig. 12 can be employed to good advantage. Here a fire-box of normal depth is maintained, while that part of the mud-ring around the combustion chamber is carried up and over the drivers, being dropped in the front center sufficiently to take care of the throat sheet. While a little unusual, this fire-box construction presents no difficulties, and no trouble has been experienced with locomotives so equipped.

It will be noticed that the front of the mud-ring is directly

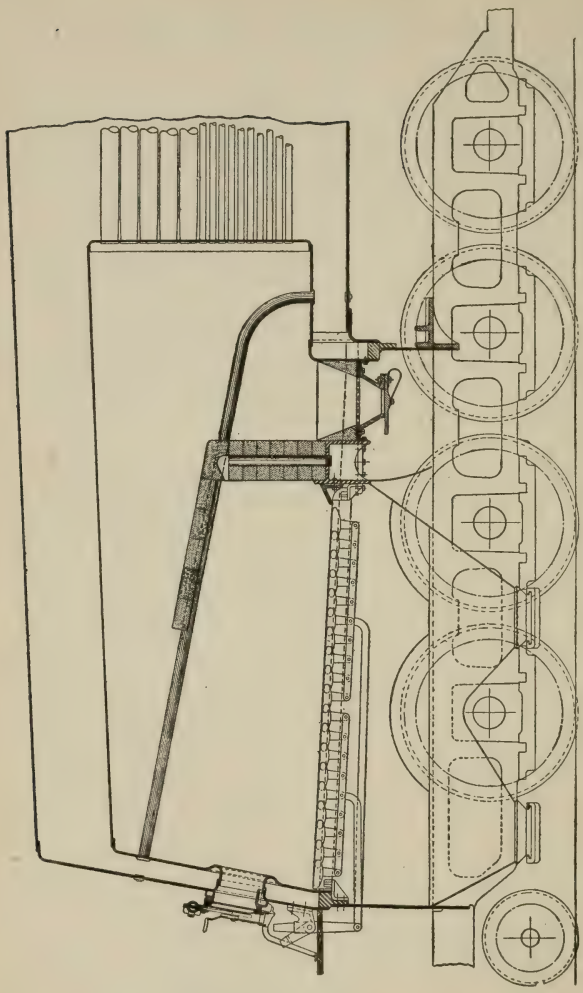


Fig. 11.
Gaines Locomotive Furnace with barrel combustion chamber as applied to a Mallet Locomotive.

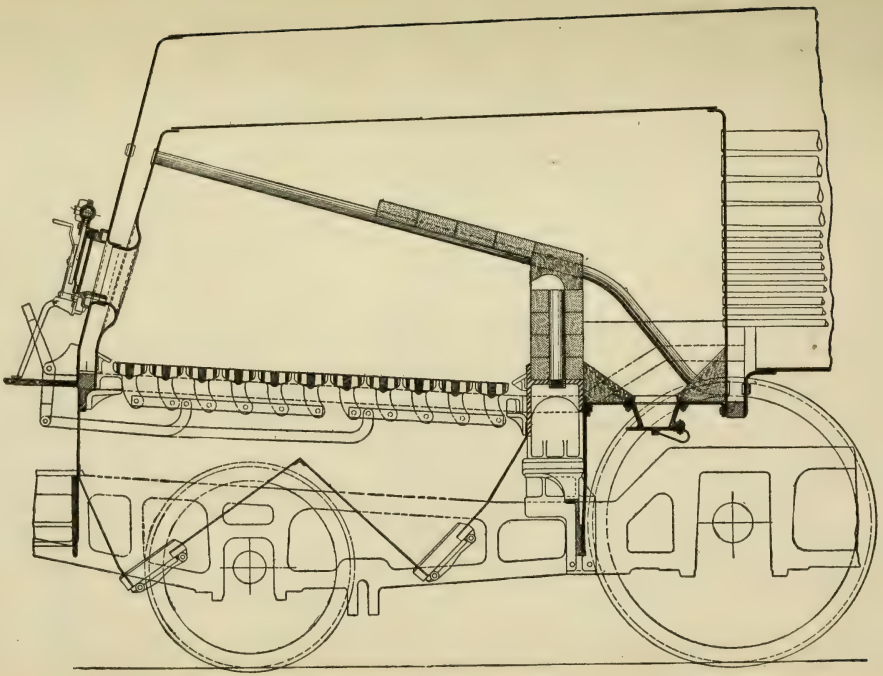


Fig. 12
Gaines Locomotive Furnace Applied to a Mikado or Pacific Type Engine with Large Drivers, Mud-ring Being Raised at Front Corners to Clear Drivers

above the pedestal and that the fire-box is unsupported at this point, the weight of the grates, furnace and fire-box being transferred to the frames back of the rear driver through the furnace bearer and frame brace; the boiler expansion is taken care of by a sliding connection between these castings.

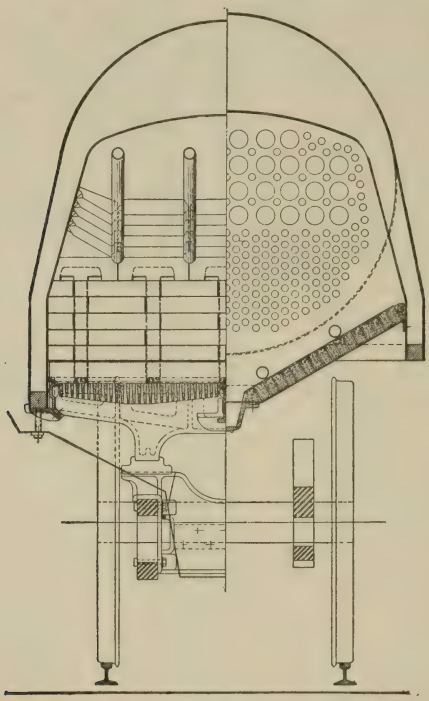


Fig. 13.
Cross section Gaines Locomotive Furnace, showing mud-ring raised at front to clear drivers. This view also illustrates method of protecting combustion chamber floor and shows air duct discharge into firebox.

This feature is illustrated in Fig. 13 which also shows the air ducts opening into the fire-box and the method of applying the combustion chamber floor.

The Gaines Locomotive Furnace meets all theoretical re-

quirements and in practice has come up to all expectations. It is simple and is easily maintained, but not "fool proof," and should receive a certain amount of attention in order to get the best results.

It has been successfully applied to old locomotives, but this is not advisable unless the grate area is so large that a part can be sacrified without greatly increasing the rate of combustion. Grate area is of prime importance and should be maintained when Gaines furnace is applied, by increasing the length of fire-box to give the necessary combustion chamber space.

Flexible stay bolts should be used behind bridge wall, "Security" arch and combustion chamber brick work; otherwise much brick work will have to be torn down unnecessarily in order to make stay bolt inspections.

An ample supply of brick should be carried at terminals in order that bridge wall and arch be maintained in good condition.

Arch tubes should receive close attention and be thoroughly cleaned out as often as water conditions demand. With clean tubes. there is little or no danger of blistering or bagging.

Particular attention should be paid to the combustion chamber at the front of bridge wall to see that no air leaks occur. Hostlers and engine crew should be instructed to keep spark hopper closed and see that full tension is maintained in spring on spark hopper cap, in order that no air leaks may occur at this point.

Firemen should not be allowed to use rakes long enough to reach bridge wall, as these brick may be damaged when heated up to a high temperature.

Engines should not be allowed to go out with air ducts in bridge wall stopped up, and if engine is not steaming properly, don't allow the crew to stop up air ducts, as the trouble lies elsewhere.

The best results have been obtained with light, level firing, and if road conditions will allow, firemen should be so instructed and engine drafted accordingly.

With intelligent handling, engines equipped with this type

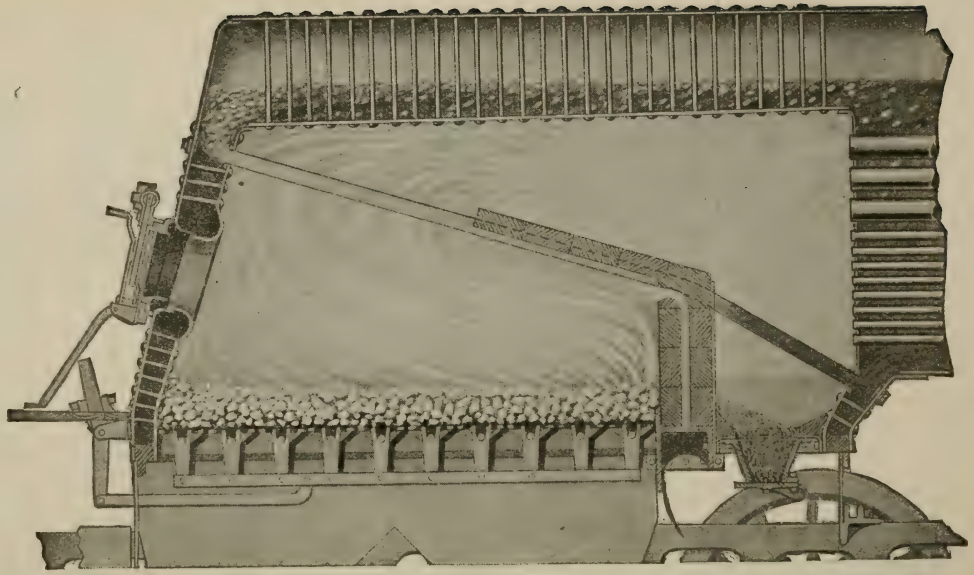


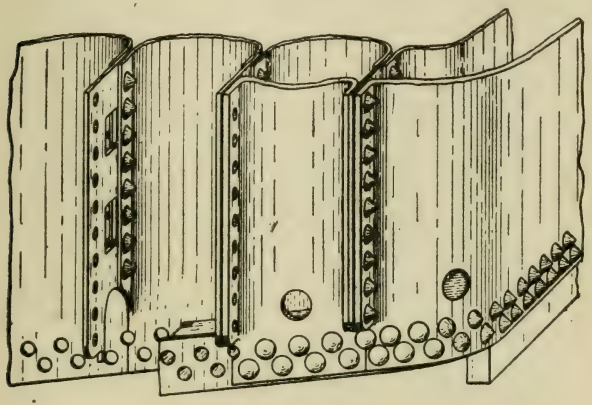
Fig. 14.

Note discharge of heated air at top of bridge wall—mixing effect of air and gas at back of arch—long flame way—complete combustion—high temperature in the combustion chamber—provisions for cinder accumulation and clean out—and protection afforded flues.

of furnace, show fuel saving of 15 to 25 per cent with total elimination of smoke and cinders as well as greatly increased life of flues.

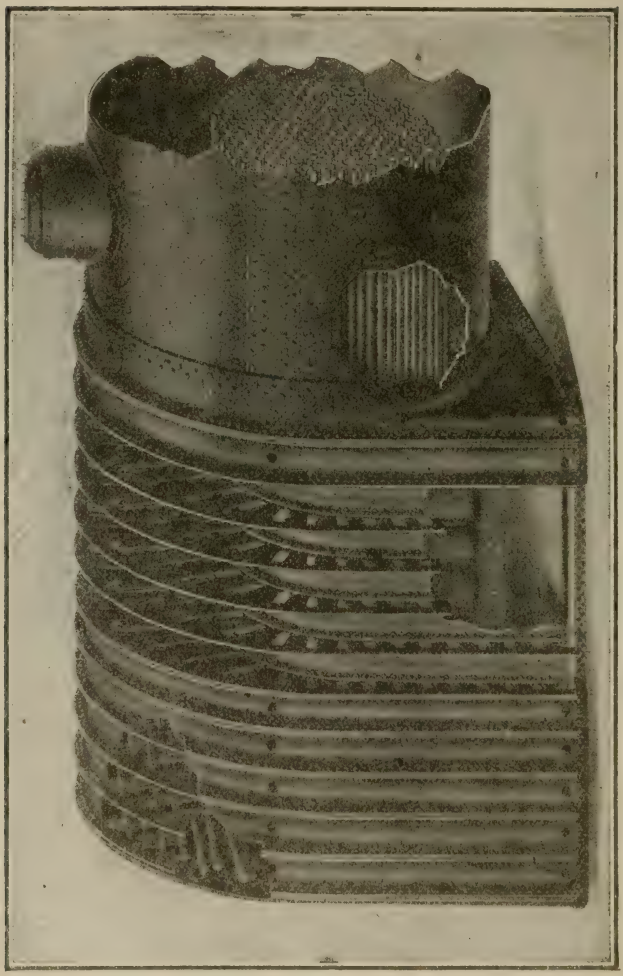
THE JACOBS-SHUPERT SECTIONAL FIRE-BOX.

The Jacobs-Shupert sectional fire-box eliminates the use of stay bolts for holding the crown and side sheets. In this construction the usual arrangement of flat sheets supported by stay bolts has been abandoned except in the front sheets



Details of butt-welded joint at mud-ring

and door sheets. The side sheets, crown sheets and wrapper sheets have been replaced by a series of semi-elliptic channel-formed sections riveted together with their flanges turned away from the fire. Stay bolts have been replaced by stay sheets. A stay sheet is interposed between each adjacent set of channel sections and is securely held thereto by the same rivets which fasten these sections together. These stay sheets are partially cut out or perforated through the water space in order to afford ample opening through which the water may pass to establish horizontal circulation. The edges of



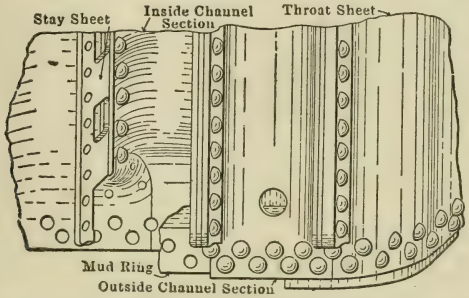
Jacobs-Shupert Sectional Locomotive Fire Box.

these stay sheets form adequate calking strips for making tight joints between adjacent channel sections.

All seams holding the inside sections together are submerged in freely circulating water and the joints of the outer or wrapper sections are accessible entirely from the outside of the fire-box.

No seams are exposed to the direct action of the fire.

The inside channel sections are flattened where they lay up against the mud ring and the edges of the flattened portions of adjacent sections are butted one against the other. This butt joint is then welded by means of the oxy-acetylene process.



Method of lapping the joints and making the connection at the mud-ring.

The flanges of the outside channel sections are cut off below the top of the mud ring and the section itself is flattened so that a plain butt joint between each section is formed along the vertical side of the mud ring. This butt joint is also riveted through the mud ring and inside section.

The mud ring is of the ordinary type and has a double row of staggered rivets.

The channel sections are made from long, flat steel sheets of proper width, heated in a furnace and then pressed into proper form of section by means of accurate formers and dies fitted to a special hydraulic flanging press. The flanges of

the section are then slightly beveled on the calking edges. The webs of the inside sections are concaved toward the fire-side while the webs of outer sections are concaved toward the outside, thus enlarging the volume of the water space.

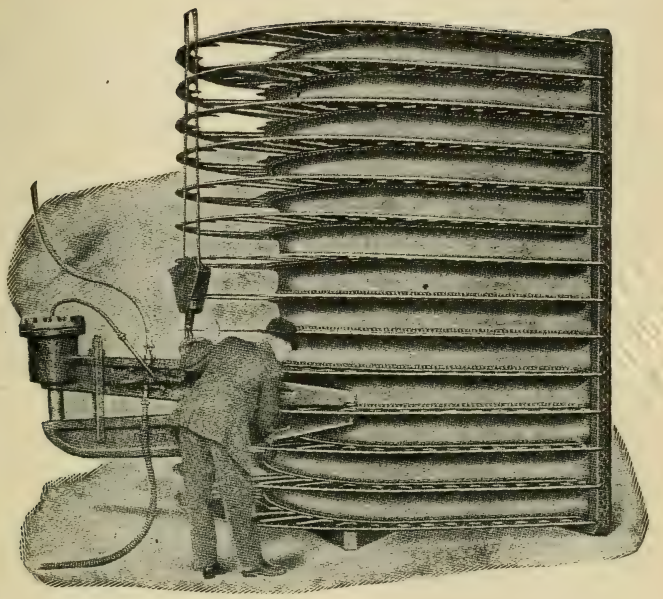
The stay sheets are made uniformly of three-eighths inch thick material. The flanged sections have a uniform extreme width of nine and five-eights inches over flanges. These dimensions refer to the standard construction.

The flue and door sheets are formed in the same manner as those commonly applied to ordinary fire-boxes except that a flange is formed in a plane parallel to the body of the sheet. This flange has the same contour as the inner channel sections and is riveted to the stay sheets just as are the sections. The flue and door sheets are commonly pressed from three to five inches deep and are joined to the sections at the mud ring in the same manner as two adjacent sections.

All channel sections, stay sheets, back head, door sheet, flue sheets and throat sheets are pressed to shape by standard dies and formers, so that perfect interchangeability is obtained. For a similar purpose, all rivet holes in channel flanges, stay sheets, door sheet, back head, flue sheet and throat sheet are drilled through standard jigs fitted with hardened bushings.

This makes the assembling exceedingly easy, and so perfect is the work that a long reamer can be run through a line of rivet holes when the sections and sheets are in proper position.

The following process is followed in assembling a fire-box: The inside sections, door sheet and tube sheet are first bolted together with stay sheets in position. These inside sections are then laid up to the mud ring and the mud ring rivet holes are drilled through the inside channels by means of an air motor drill. All rivet holes are then reamed. The inside sections with interposed stay sheets are then riveted together by means of a special slim jawed portable hydraulic gap riveter, which is supported by a flexible cable near its center of gravity so it can be easily moved and manipulated. All inside channel section flanges and stay sheet seams are then chipped and calked.



Method of Riveting Together the Channel Sections and Stay-Sheets by Means of Gap Riveter

The outside channel sections are then set in position between the stay sheets and temporarily bolted in place, together with the back head. All seam rivet holes are reamed, outside sections are chipped and laid up to the mud ring and rivet holes are drilled through the outside sections from the inside of fire-box.

The outside section seam rivets are then driven by means of the gap riveter above mentioned.

All back head T irons are applied to the back head, which is then bolted in position and the corners laid up to the mud ring.

The rivets connecting the back head as well as the throat sheet to the outside sections are now driven by means of the special gap riveter.

All mud ring rivets are next driven with a bull riveter, after which the corner plug holes are drilled and tapped and the plugs applied.

All outside seams between the flanges of the sections, throat sheet and back head, as well as all laps and rivets at mud ring, are now calked.

Door hole flange is next laid up and patch bolt holes are drilled and tapped and the plugs applied. These plugs, together with the door-hole flange, are then calked.

All stay bolt holes in lower leg of throat sheets and flue sheet and in back head and door sheet are tapped and the stay bolts applied and riveted over.

Back head brace rods are applied and the brace feet rivets are calked.

The fire-box is then ready to be applied to the boiler shell.

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